

Floral survey of the diatom genera *Cymbella* and *Gomphonema* (Cymbellales, Bacillariophyta) from the Jolmolungma Mountain Region of China

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Abstract – We report on taxa from the diatom genera *Gomphonema* and *Cymbella* (Cymbellales, Bacillariophyta) found in the Jolmolungma Mountain region of China. This region is unique for its diversity of habitats, which include rivers, springs, moist soil, snowfields, swamps and lakes. We re-examine diatom taxa found in samples first documented in 1973 (Jao *et al.*, 1973) and incorporate recent taxonomic revisions from the literature. In the genera *Gomphonema* and *Cymbella* we report 113 species and varieties. Of these 113 taxa, 59 are new record for China; 1 new combination, *Encyonema jolmolungmensis*, is made. Morphometric data and habitat features are reported for each taxon. Their distribution is strongly correlated to their microhabitats.

***Cymbella* / *Gomphonema* / Bacillariophyta / Jolmolungma Mountain Region / China**

Résumé – Report floristique des genres de diatomées *Cymbella* et *Gomphonema* (Cymbellales, Bacillariophyta) du Mont Jolmolungma, Chine. Cet article présente les taxons appartenant aux genres de diatomées *Gomphonema* and *Cymbella* (Cymbellales, Bacillariophyta) trouvés dans le Mont Jolmolungma, Chine. Cette région est unique par la diversité de ses habitats : rivières, cascades, sol humide, champs de neige, marécages et lacs. Les auteurs re-examinent les taxons trouvés en 1973 (Jao *et al.*, 1973) et incorporent des révisions taxonomiques récentes de la littérature. 113 espèces et variétés de *Gomphonema* et de *Cymbella* ont été déterminées ; parmi elles, 59 sont nouvelles pour la Chine et 1 nouvelle combinaison est proposée : *Encyonema jolmolungmensis*. Des données morphométriques et sur l'habitat sont précisées pour chaque taxon. Leur distribution est fortement corrélées aux microhabitats.

***Cymbella* / *Gomphonema* / Bacillariophyta / Mont Jolmolungma / Chine**

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INTRODUCTION

The Jolmolungma Mountain region, the highest in the world (Alt. 8848m), is located in the middle of the Himalayan Mountains on the border between Xizang (Tibet) of China and Nepal. It is bordered on the north by the high plateau of the Qinghai-Xizang Plateau and on the south by the plains of the Indian subcontinent. The weather is very cool and arid to the north, warm and humid to the south (Li *et al.*, 1992).

There have been only a few studies on the diatoms from Xizang (Tibet) and adjoining regions (Dickie, 1885; Mereschkowsky, 1906; Hustedt, 1922; Skvortzow, 1938, 1969; Skuja, 1937; Hirano, 1955; Jao, 1964; Jao *et al.*, 1973; Zhu & Chen, 1989, 1994, 2000; Jüttner *et al.*, 1996; Rothfritz *et al.*, 1997; Jüttner *et al.*, 2000; Cantonati *et al.*, 2001; Li *et al.*, 2002, 2003; Jüttner *et al.*, 2003; Jüttner *et al.*, 2004). The algal flora (including some diatom species) from the Jolmolungma Mountain region of China was studied by Jao *et al.* (1973). However, during the past 10 years taxonomic revisions have continued to accumulate in the diatom literature with many genera being recognised as artificial and split into what might now be considered more natural groupings. Recent treatments included the genus *Cymbella* C.A. Agardh, species of which are now distributed among 11 genera: *Cymbella*, *Encyonema* Kütz., *Pseudoencyonema* Krammer, *Encyonopsis* Krammer, *Reimeria* Kociolek *et* Stoermer, *Cymbellopsis* Krammer, *Cymbopleura* (Krammer) Krammer, *Navicymbula* Krammer, *Delicata* Krammer, *Gomphocymbellopsis* Krammer and *Afrocymbella* Krammer (Kociolek & Stoermer, 1987; Round *et al.*, 1990; Krammer, 1997a, 1997b, 2002, 2003).

Among the many revisions within the Cymbellales are a number of species that are widespread, frequently encountered or important for China (Reichardt & Lange-Bertalot, 1991; Reichardt, 1999). In this paper we present a checklist of taxa from the genera *Cymbella sensu lato* and *Gomphonema sensu lato* that have been reported from the Jolmolungma Mountain region and comment on the distribution of taxa in waters of this region. The earlier summary of taxa in the genera *Cymbella* and *Gomphonema* from this region (Jao *et al.*, 1973) has become rather dated. We present this checklist with the names of taxa as initially reported in the literature but include current nomenclature. In addition, new distributional records are given for 59 taxa.

Our aim is to assist in the promotion of further distributional and applied studies on diatoms from the Jolmolungma Mountain Region and contribute to future taxonomic consistency.

MATERIALS AND METHODS

Samples were collected from the Jolmolungma Mountain Region (27-29°N, 85-89°E) during May and June 1966. Descriptions of the location, altitude, habitat, water temperature, air temperature and pH at the sampling sites are in Table 1. Samples were collected with a plankton net or scraped directly from stones. The collected samples were fixed in 5% formalin and preserved in the Herbarium of the Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan City, P. R. China. Organic matter was removed according to the method of Hu *et al.* (1980) and Patrick & Reimer (1966). Diatoms were identified using

oil immersion at 1000x magnification under the BX51 Olympus microscope. Identification was performed using a variety of studies, primarily Schmidt *et al.* (1874-1959), Hustedt (1930), Cleve-Euler (1955), Patrick & Reimer (1975), Krammer & Lange-Bertalot (1986, 1991), Round *et al.* (1990), Krammer (1997a, 1997b, 2002, 2003), Zhu & Chen (2000), but additionally a number of other reports were consulted (Sarode & Kamat, 1980; Qi & Yang, 1985; Houki, 1986; Germain, 1986; Watanabe & Usman, 1987; Compère, 1990; Mizyno & Saito, 1990; Kociolek *et al.*, 1991; Reichardt & Lange-Bertalot, 1991; Cater & Patrick, 1992; Paul & Steinitz-Kannan, 1992, Douglas & Smol, 1993; Yamakawa, 1994; Shiono & Jordan, 1995; Haraguchi, 1997; Tatsuya, 1997; Nigorikawa & Hasegawa, 2000).

For each taxon valve length, breadth, and striae characteristics are provided, along with information on their habitat. After each taxon name, pertinent literature is given. Figures are given for each species.

Table 1. Description of location, altitude, water temperature, air temperature and pH at sampling sites: WT, water temperature, AT, air temperature, N, north of the Jolmolungma Mountain region, S, south of the Jolmolungma Mountain region.

Sample	Locality	Habitat	Alt. (m)	WT (°C)	AT (°C)	pH
116a	Dingri County, N	Stone and humid soil in fountain	4950	16	20	8.0
116b	Dingri County, N	Flowing fountain	4950	16	20	8.0
116c	Dingri County, N	Still water	4950	16	20	8.0
118a	Dingri County, N	Flowing water	5500	3	14	8.0
118b	Dingri County, N	Humid soil	5500	3	14	8.0
119	Dingri County, N	Ditch and humid soil	5500			8.5
101	Zhangmu Country, S	Stream	1668	16	24	5.0
109	Zhangmu Country, S	Stone in rushed stream	1668	11	19	6.5
110	Zhangmu Country, S	Spring	2380	13	23	6.0
136	Zhangmu Country, S	Stone, stick and humid soil	1750	18	28	5.0
114a	Dingri County, N	Narrow of stream	4950	16	20	8.0
114b	Dingri County, N	Broad of stream	4950	16	20	8.0
114c	Dingri County, N	Swamp by stream	4950	16	20	8.0
121	Dingri County, N	Spring	5100	15	12	8.0
123	Dingri County, N	Stream	5000	7	16	8.0
124	Dingri County, N	Ditch	5000	21	16	8.5
125	Dingri County, N	Stream	4570	20	17	8.0
127	Dingri County, N	Rea snow	5000			
129	Nielamu Country, N	Stone in lake	4750	14	13.5	10
130	Nielamu Country, N	Spring	4750	14	13.5	8.5
131	Nielamu Country, N	Manqu river	4750	10	22	8.5
132	Nielamu Country, N	Swamp beside lake	4750	23	18	8.5
133	Jiacun Country, S	Stream	4280	10	24	5.5
134	Tulong Country, S	Boqu river	4400	15	20	7.0
135a	Zhangmu Country, S	Rushed stone and soil in stream	2750	13.5	16.5	6.0
135b	Zhangmu Country, S	Stream	2750	13.5	16.5	6.0
138	Zhangmu Country, S	Spring	2350	25	27	6.0
137	Zhangmu Country, S	Stone in stream	2350	17	27	7.0
139	Zhangmu Country, S	Stream	2350	18	30	6.5

RESULTS AND DISCUSSION

Given the wide range of habitat types found in the Jolmolungma Mountain region, the diversity of *Cymbella* and *Gomphonema* has been underestimated. In other parts of the world with higher mountains that have been more intensively sampled, greater species richness is still evident. For example, in the Andes 162 cymbelloid and gomphonemoid taxa were reported (Rumrich *et al.*, 2000); even in a single large lake system, such as the Laurentian Great Lakes in USA, 222 taxa were discovered (Stoermer *et al.*, 1999).

For *Cymbella sensu lato* and *Gomphonema sensu lato* 113 species and varieties are recorded from the Jolmolungma Mountain region of China, 59 of which have been recorded for the first time in China. Broadly speaking, some taxa are arctic and alpine forms, while others are unique to the Qingzang Plateau (Jao *et al.*, 1973).

Two factors may account for the seemingly low taxon richness of this Cymbelloid and Gomphonemoid flora. First, the number of samples – 29 (see Table 1) – was not sufficient to cover the entire range of diversity – a characteristic diatom flora was evidently absent in the region. A second factor was the lack of an intensive surveying effort directed towards these organisms. For instance, epiphytic diatoms in the region received hardly any attention.

In all, 95 taxa are found to the north of the Jolmolungma Mountain region, with only 68 in the south. This difference may be related to contrasting natural conditions between the north and south of this region. The samples from the south of the Jolmolungma Mountain region (except sample 135b, collected from a puddle) were from flowing water bodies, while the sample from the north region were collected from a variety of water bodies (e.g. still waters, lakes, swamps, springs, humid soil and snow). In addition, some environmental conditions were more rigorous in the south than in the north region. For example, there were lower pH readings in the south (5.0-7.0) than the north (7.5-10). These natural factors may have a great effect on diatom distributions, consistent with parameters for the distribution of other members of the alga flora, including Cyanobacteria, Euglenophyta, Chlorophyta, Rhodophyta, Pyrrophyta, Chrysophyta, Xanthophyta and Charophyta in this region (Jao *et al.*, 1973).

In the north Jolmolungma Mountain region, red snow (sample 127) was collected at an altitude of 5000 m. Some characteristic snow algae, *Chlamydomonas nivalis* Wolle, *Ankistrodesmus nivalis* (Chod.) Brunth., and *Chlorococcum influsionum* (Schr.) Menegh., were found in the sample (Li *et al.*, 1992). We also found 20 species from *Cymbella* and *Gomphonema*. Most species in these genera are either arctic or alpine forms. They are not known to be associated with other snow algae; most of the specimens were dead when they were collected (Jao *et al.*, 1973); their presence might be explained by wind dispersal.

Using a combination of the literature review and our survey work, the diatom flora of the Mountain Jolmolungma region is increased to 59 taxa. Since there is only limited information for some areas and habitats, further studies are required to establish the total number of species in the floras as well as its uniqueness.

Flora List

Cymbopleura (Krammer) Krammer

Cymbopleura amphicephala (Naegeli) Krammer (Fig. 1)

Krammer (2003: 70, pl. 91, figs 1-18).

Valves slightly dorsi-ventral, with arched dorsal and ventral margin; poles capitate or rostrate; axial area narrow, central area small or absent; striae radiate. Length 25-35 μm , breadth 7-9.5 μm , striae 9 to 18 in 10 μm . Habitat: pH 5.0-8.0, air temperature 12-28°C, water temperature 15-18°C, altitude 1750-5100 m. Present in samples: 121, 136. Distributed in Sichuan, Shanxi and Heilongjiang (Gao, 1987; Fan *et al.*, 1993; Zhong *et al.*, 1986).

Cymbopleura citrus (Carter *et* Bailey-Watts) Krammer (Figs 2-3)

Krammer (2003: 67, pl. 97, figs 5-12).

Valves slightly dorsi-ventral, ventral and dorsal margin arched; poles apiculate to sub-capitate; axial area narrow, central area small; striae radiate. Length 15-28 μm , breadth 7-10 μm , striae 11 to 18 in 10 μm . Habitat: pH 5.5-8.5, air temperature 12-24°C, water temperature 10-21°C, altitude 1668-5100 m. Present in samples: 109, 114c, 121, 124, 125, 133, 134, 135b. **This is a new record for China.**

Cymbopleura elliptica Krammer (Fig. 4)

Krammer (2003: 68, pl. 89, figs 15-17).

Valves barely dorsi-ventral, linear-elliptical with straight ventral and dorsal margins; poles narrowly capitate; axial area wide, linear, central area large, more than 1/2 the valve breadth, rhomboid; striae radiate. Length 40-45 μm , breadth 11-12 μm , striae 12 to 20 in 10 μm . Habitat: pH 8.0, air temperature 12-16°C, water temperature 7-15°C, altitude 5000-5100 m. Present in samples: 121, 123. **This is a new record for China.**

Cymbopleura florentina var. *brevis* Krammer (Fig. 5)

Krammer (2003: 100, pl. 119, figs 16-18).

Valves slightly dorsi-ventral with nearly straight to convex ventral margin; poles broadly rounded to truncate; central area small, rounded, sometimes slightly unilateral either to the dorsal or ventral side; raphe lateral; striae radiate. Length 37-54 μm , breadth 7.5-9.5 μm , striae 8 to 16 in 10 μm . Habitat: pH 5.5-8.5, air temperature 12-24°C, water temperature 7-23°C, altitude 2380-5500 m. Present in samples: 119, 110, 114a, 114b, 114c, 121, 123, 124, 125, 127, 130, 131, 132, 133, 134. **This is a new record for China.**

Cymbopleura fluminea (R. Patr. *et* Freese) Lange-Bertalot *et* Krammer (Fig. 6)

Krammer (2003: 64, pl. 88, figs 7-11).

Valves slightly dorsi-ventral, linear with arched dorsal margin and straight ventral margin; poles capitate to sub-capitate; axial area narrow, central area small; striae radiate. Length 30-38 μm , breadth 6-8.5 μm , striae 11 to 18 in 10 μm . Habitat: pH 6.0-8.5, air temperature 17-23°C, water temperature 13-23°C, altitude 2380-4950 m. Present in samples: 110, 116b, 125, 132. **This is a new record for China.**

***Cymbopleura hercynica* (A. Schmidt) Krammer (Fig. 7)**

Krammer (2003: 72, pl. 96, figs 19-21).

Valves slightly dorsi-ventral, elliptical-lanceolate with convex ventral and dorsal margin; poles narrowly rounded, sub-rostrate to rostrate; axial area narrow, central area slightly ovoid or small; striae radiate. Length 25-35 μm , breadth 8.5-10.5 μm , striae 9 to 18 in 10 μm . Habitat: pH 6.0, air temperature 23°C, water temperature 13°C, altitude 2380. Present in sample: 110. **This is a new record for China.**

***Cymbopleura hustedtiana* Krammer (Fig. 8)**

Krammer (2003: 81, pl. 101, figs 9-13).

Valves slightly dorsi-ventral with convex to nearly straight ventral margin and convex dorsal margin; poles short, broadly truncate; axial area narrow, linear, central area small or absent; striae radiate. Length 32-52 μm , breadth 10-14.5 μm , striae 10 to 20 in 10 μm . Habitat: pH 8.5, air temperature 18°C, water temperature 23°C, altitude 4750 m. Present in sample: 132. **This is a new record for China.**

***Cymbopleura incertiformis* Krammer (Figs 9, 10)**

Krammer (2003: 92, pl. 109, figs 2-11).

Valves slightly dorsi-ventral, linear sub-elliptical with convex to nearly straight ventral margin and convex dorsal margin; poles broadly truncate; axial area narrow, linear, central area small, elliptical; striae slightly radiate, becoming radiate towards the poles. Length 30-40 μm , breadth 6-7.5 μm , striae 14 to 20 in 10 μm . Habitat: pH 8.0, air temperature 17°C, water temperature 20°C, altitude 4570 m. Present in sample: 125. **This is a new record for China.**

***Cymbopleura krasskei* (Foged) Krammer (Fig. 11)**

Krammer (2003: 107, pl. 127, figs 28-31).

Valves slightly dorsi-ventral with nearly straight dorsal and ventral margins, dorsal margin more convex than ventral; poles broadly rounded; axial area narrow, central area small, sometimes slightly unilateral, either to the dorsal or ventral side; raphe slightly lateral; striae radiate. Length 22-25 μm , breadth 5.5-7 μm , striae 9 to 18 in 10 μm . Habitat: air temperature 17°C, water temperature 20°C, pH 8.0, altitude 4570 m. Present in sample: 125. **This is a new record for China.**

***Cymbopleura kuelbsii* Krammer (Figs 12-14)**

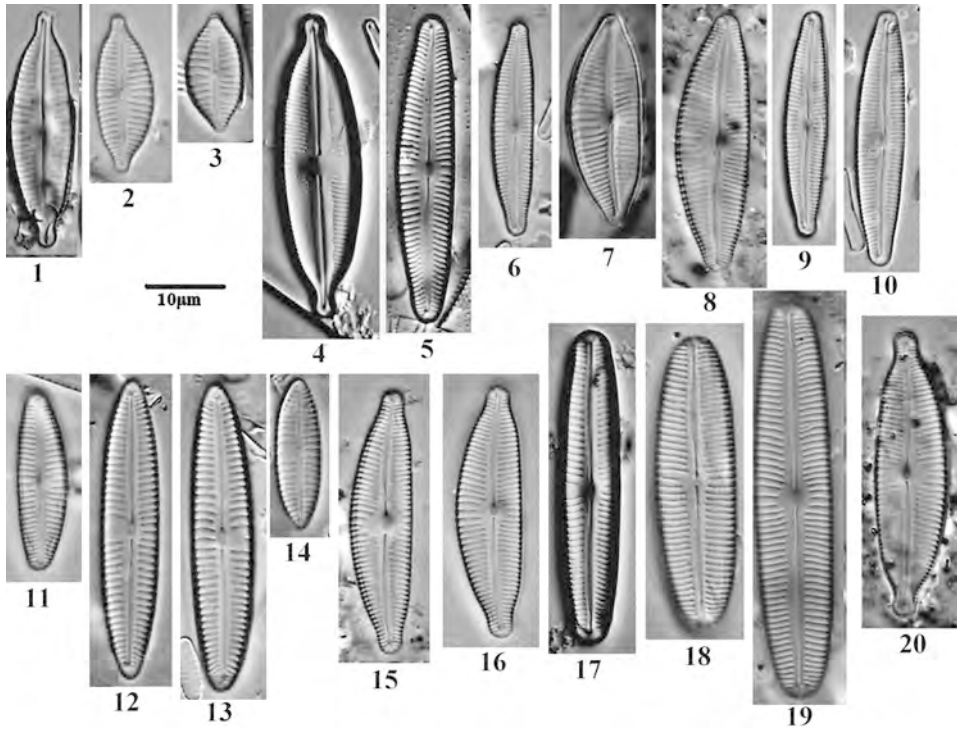
Krammer (2003: 94, pl. 113, figs 1-7b).

Valves slightly dorsi-ventral with nearly straight dorsal and ventral margin, dorsal margin more convex than ventral; poles broadly rounded; axial area narrow, central area small, sometimes slightly unilateral either to the dorsal or ventral side; raphe slightly lateral; striae radiate. Length 25-43 μm , breadth 7.5-9 μm , striae 8 to 18 in 10 μm . Habitat: pH 6.5-8.5, air temperature 13.5-20°C, water temperature 11-20°C, altitude 1668-5000 m. Present in samples: 116b, 109, 114c, 125, 127, 130. **This is a new record for China.**

***Cymbopleura linearis* (Foged) Krammer (Fig. 15)**

Krammer (2003: 59, pl. 89, figs 1-11).

Valves distinctly dorsi-ventral, elliptical-lanceolate with convex ventral and dorsal margins; poles apiculate-rostrate; axial area narrow, central area large,



Figs 1-20. **1.** *Cymboplectra amphi-cephala* (Nägeli) Krammer. **2-3.** *Cymboplectra citrus* (Carter et Bailey-Watts) Krammer. **4.** *Cymboplectra elliptica* Krammer. **5.** *Cymboplectra florentina* var. *brevis* Krammer. **6.** *Cymboplectra fluminea* (Patr. et Freese) Lange-Bert. et Krammer. **7.** *Cymboplectra hercynica* (Schmidt) Krammer. **8.** *Cymboplectra hustediana* Krammer. **9, 10.** *Cymboplectra incertiformis* Krammer. **11.** *Cymboplectra krasskei* (Foged) Krammer. **12-14.** *Cymboplectra kuelbsii* Krammer. **15.** *Cymboplectra linearis* (Foged) Krammer. **16.** *Cymboplectra naviculiformis* (Auers.) Krammer et Lange-Bert. **17.** *Cymboplectra oblongata* Krammer. **18, 19.** *Cymboplectra oblongata* var. *streptoraphe* Krammer. **20.** *Cymboplectra sublanceolata* Krammer.

about 1/2 the valve breadth; striae radiate. Length 35-42 µm, breadth 8-9 µm, striae 11 to 18 in 10 µm. Habitat: pH 8.0-8.5, air temperature 17-18°C, water temperature 20-23°C, altitude 4570-4750 m. Present in samples: 125, 132. **This is a new record for China.**

***Cymboplectra naviculiformis* (Auers.) Krammer et Lange-Bertalot (Fig. 16)**
Krammer (2003: 56, pl. 79, figs 1-14).

Valves moderately dorsi-ventral, elliptic lanceolate, asymmetrically naviculoid; poles produced capitate; axial area linear, central area broad, rhomboid; striae radiate. Length 27.5-45 µm, breadth 9-12 µm, striae 12 to 20 in 10 µm. Habitat: pH 5.5-8.5, air temperature 16-27°C, water temperature 7-25°C, altitude 2350-5000 m. Present in samples: 110, 114a, 114c, 123, 125, 132, 133, 134, 135a, 137, 138, 139. Distributed in Tibet, Sichuan, Xinjiang, Hunan, Qinghai, Guizhou and Yunnan Provinces (Zhu & Chen, 1989, 1994 & 2000; Bao *et al.*, 1986; Zhong *et al.*, 1986; Wang, 1997; Wei *et al.*, 1994; Li *et al.*, 2002).

Cymbopleura oblongata* Krammer*(Fig. 17)**

Krammer (2003: 104, pl. 122, figs 2-4).

Valves slightly dorsi-ventral with nearly straight dorsal and ventral margins; poles obtusely rounded; axial area narrow, central area small, rounded, sometimes slightly unilateral either to the dorsal or ventral side; raphe slightly lateral; striae radiate. Length 35-45 μm , breadth 7-9 μm , striae 8 to 13 in 10 μm . Habitat: pH 5.5-8.5, air temperature 16-24°C, water temperature 7-23°C, altitude 4280-5500 m. Present in samples: 114c, 119, 121, 123, 124, 125, 130, 132, 133, 134. **This is a new record for China.**

Cymbopleura oblongata* var. *streptoraphe* Krammer*(Figs 18, 19)**

Krammer (2003: 104, pl. 122, figs 5-8).

Valves slightly dorsi-ventral with nearly straight dorsal and ventral margins; poles broadly rounded; axial area moderately wide, about 1/4 the valve breadth, central area small, rounded, sometimes slightly unilateral either to the dorsal or ventral side; raphe strongly reverse-lateral; striae radiate. Length 50-62 μm , breadth 9.5-11.5 μm , striae 7 to 10 in 10 μm . Habitat: pH 8.0-8.5, air temperature 12-18°C, water temperature 15-23°C, altitude 4750-5100 m. Present in samples: 121, 132. Differs from Krammer's description by moderately wide axial area. **This is a new record for China.**

Cymbopleura sublanceolata* Krammer*(Fig. 20)**

Krammer (2003: 59, pl. 82, figs 1-11).

Valves dorsi-ventral, linear-lanceolate; poles abruptly cuspidate; axial area narrow, central area rounded; striae radiate. Length 36.5-42 μm , breadth 9.5-10.5 μm , striae 9 to 20 in 10 μm . Habitat: pH 8.0, air temperature 16°C, water temperature 7°C, altitude 5000 m. Present in sample: 123. **This is a new record for China.**

Cymbopleura rupicola* var. *minor* Krammer*(Fig. 21)**

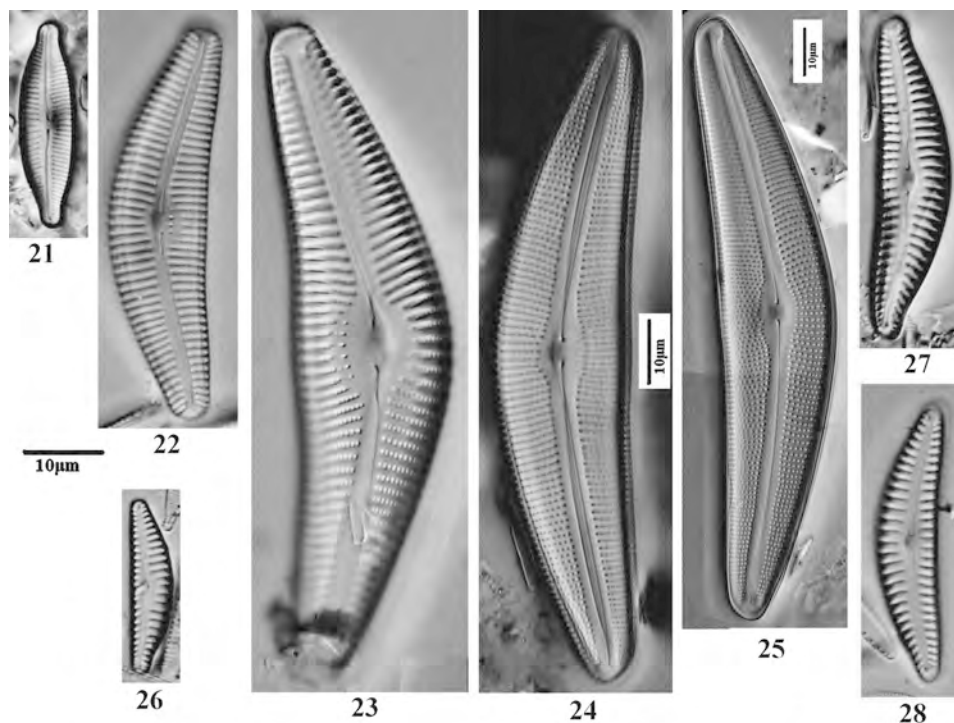
Krammer (2003: 47, pl. 67, figs 1-8).

Valves slightly dorsi-ventral, linear-lanceolate; poles rostrate; axial area narrow, slightly lanceolate, central area small, variable; striae parallel or slightly radiate at the centre, becoming distinctly radiate toward the poles. Length 22-31 μm , breadth 6-8.5 μm , striae 10 to 22 in 10 μm . Habitat: pH 8.0-8.5, air temperature 11°C, water temperature 17°C, altitude 5500-5700 m. Present in samples: 119, 116c, 116a. **This is a new record for China.**

Cymbella* C.A. Agardh**Cymbella arctica* (Lagerstedt) A. W. F. Schmidt****(Fig. 22)**

Krammer (2002: 102, pl. 104, figs 1-8).

Valves strongly dorsi-ventral with strongly arched dorsal margin and slightly concave ventral margin; poles broadly truncate or rounded; axial area narrow, linear, central area small, somewhat rounded; isolated stigmata (2-5) in ventral portion of central area; striae slightly radiate, becoming more radiate towards the poles. Length 54-65 μm , breadth 13-15 μm , striae 9 to 13 in 10 μm . Habitat: pH 7.0-8.0, air temperature 14-20°C, water temperature 3-20°C, altitude 4400-5500 m. Present in samples: 118b, 123, 125, 134. **This is a new record for China.**



Figs 21-28. **21.** *Cymbopleura rupicola* var. *minor* Krammer. **22.** *Cymbella arctica* (Lagerstedt) A. Schmidt. **23.** *Cymbella arctissima* Metzeltin. **24, 25.** *Cymbella aspera* Ehr. **26.** *Cymbella botellus* (Lagerstedt) A.Schmidt. **27, 28.** *Cymbella cleve-eulerae* Krammer.

***Cymbella arctissima* Metzeltin (Fig. 23)**
 Krammer (2002: 104, pl. 106, figs 1-3).

Valves dorsi-ventral with moderately convex dorsal margin and slightly concave ventral margin with tumid centre; poles broadly truncate; axial area moderately wide, central area large, rounded; isolated stigmata (3-8) on the ventral side of central area, additional isolated stigmata (1-2) present on the dorsal side of the central area; striae radiate. Length 80-92 µm, breadth 20-22 µm, striae 7 to 12 in 10 µm. Habitat: pH 8.0, air temperature 16-17°C, water temperature 7-20°C, altitude 4570-5000 m. Present in samples: 123, 125. **This is a new record for China.**

***Cymbella aspera* (Ehrenb.) Cleve (Figs 24, 25)**
 Schmidt *et al.* (1931: 375, fig.1), Hustedt (1930: 365, fig. 680).

Valves dorsi-ventral with broadly convex dorsal margin and slightly concave ventral margin with tumid centre; poles broadly truncate or rounded; axial area linear, broad, central area lanceolate; striae radiate. Length 110-148 µm, breadth 22-27 µm, striae 7 to 14 in 10 µm. Habitat: pH 8.0, air temperature 20-27°C, water temperature 16-25°C, altitude 2350-4950 m. Present in samples: 114a, 114c, 137, 138, 139. Distributed widely in China.

***Cymbella botellus* (Lagerstedt) A. W. F. Schmidt (Fig. 26)**

Krammer (2002: 105, pl. 107, figs 11-16).

Valves slightly dorsi-ventral with arched dorsal and straight ventral margins; poles narrowly rounded; axial area narrow, central area small or absent; striae slightly radiate, more radiate towards the poles. Length 15-30 μm , breadth 4.5-6.5 μm , striae 8 to 12 in 10 μm . Habitat: pH 8.0, air temperature 12-20°C, water temperature 15-16°C, altitude 4950-5100 m. Present in samples: 114c, 121. **This is a new record for China.**

***Cymbella cleve-eulerae* Krammer (Figs 27, 28)**

Krammer (2002: 105, pl. 107, figs 1-10).

Valves arcuate with arched dorsal and concave to straight ventral margins; poles narrowly rounded, axial area narrow, central area small or absent; striae slightly radiate, more radiate toward the poles. Length 35-45 μm , breadth 6.5-10 μm , striae 8 to 12 in 10 μm . Habitat: pH 5.5-8.5, air temperature 12-30°C, water temperature 3-20°C, altitude 1668-5500 m. Present in samples: 116b, 116c, 118b, 109, 114a, 114b, 114c, 121, 123, 125, 127, 130, 131, 133, 134, 139. **This is a new record for China.**

***Cymbella cymbiformis* C.A. Agardh (Fig. 29)**

Krammer & Lange-Bertalot (1986: 317, fig. 129, 2-9).

Valves dorsi-ventral with slightly concave ventral margin, slightly tumid at the centre; axial area linear, arched, central area slightly rounded; isolated stigmata (1-3) on the ventral side of central area; striae slightly radiated. Length 60-105 μm , breadth 12-18 μm ; striae 9 to 18 in 10 μm . Habitat: pH 6.0-10, air temperature 12-30°C, water temperature 7-25°C, altitude 2350-5100 m. Present in samples: 114b, 114c, 121, 123, 124, 125, 127, 129, 130, 131, 132, 135a, 137, 138, 139. Distributed in Tibet, Sichuan, Hunan, Qinghai, Guizhou and Yunnan (Zhu & Chen, 1989, 1994 and 2000; Qian *et al.*, 1986; Wei *et al.*, 1994; Mereschkowsky, 1906).

***Cymbella cymbiformis* var. *nonpunctata* Fontell (Figs 30, 31)**

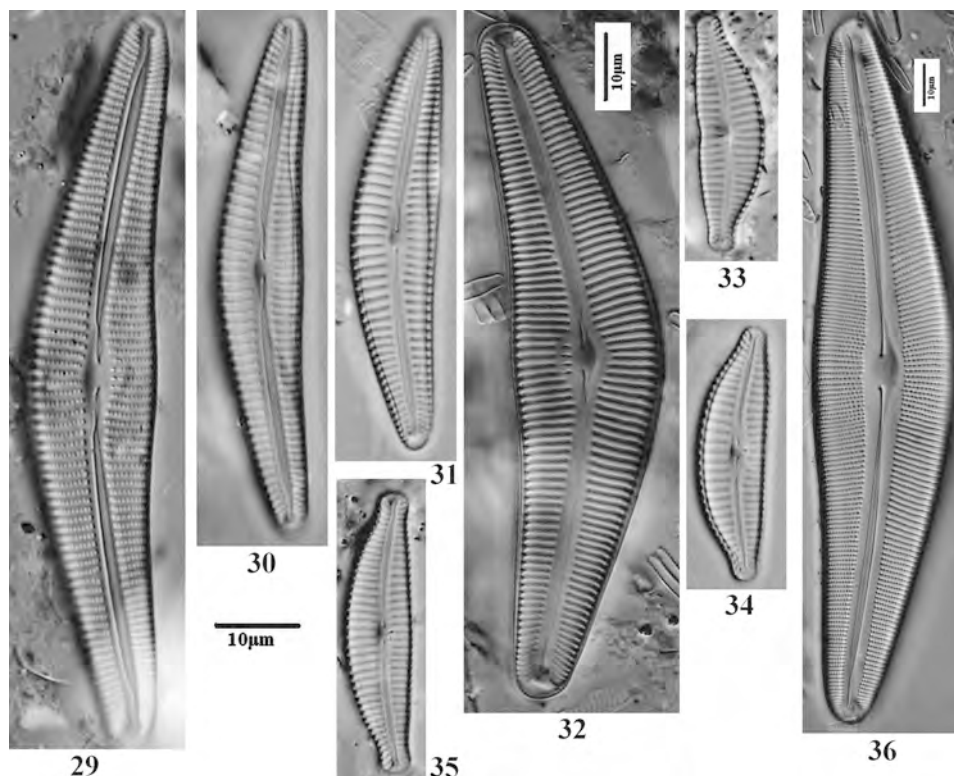
Patrick & Reimer (1975: 55, pl. 10, fig. 5), Cleve-Euler (1955: 160, fig. 1246 e-f).

Differs from the nominate variety by isolated stigma lacking on the ventral side of central area. Length 54.5 μm , breadth 11.5 μm , striae 7 to 14 in 10 μm . Habitat: pH 8.5, air temperature 13.5°C, water temperature 14°C, altitude 4750 m. Present in sample: 130. Distributed in Tibet, Sichuan, Hunan, Jilini, Guizhou and Yunnan (Zhu & Chen, 1989, 1994 and 2000; Qian *et al.*, 1986; Wei *et al.*, 1994; Bao *et al.*, 1992).

***Cymbella dorsenotata* Østrup (Fig. 32)**

Krammer (2002: 98, pl. 98, figs 1-6).

Valves strongly dorsi-ventral, dorsal margin convex and ventral margin concave with distinctly tumid centre; poles broadly rounded; axial area narrow, central area moderately large, rounded; isolated stigmata (4-5) in ventral portion of central area; striae radiate. Length 93-115 μm , breadth 20-25 μm , striae 8 to 12 in 10 μm . Habitat: pH 8.0-10, air temperature 12-20°C, water temperature 3-23°C, altitude 4570-5100 m. Present in samples: 114a, 114b, 121, 123, 125, 129, 130, 132. **This is a new record for China.**



Figs 29-36. **29.** *Cymbella cymbiformis* Agardh. **30, 31.** *Cymbella cymbiformis* var. *nonpunctata* Font. **32.** *Cymbella dorsenotata* Østrup. **33.** *Cymbella excisa* Kütz. **34.** *Cymbella excisa* var. *procera* Krammer. **35.** *Cymbella excisiformis* Krammer. **36.** *Cymbella halophila* Krammer.

***Cymbella excisa* Kütz. (Fig. 33)**

Schmidt et al. (1887: 71, figs 35-36), Zhu & Chen (2000: 209, pl. 38, fig. 11).

Valves dorsi-ventral with convex dorsal margin and strongly concave ventral margin at the centre; poles sub-rostrate to rostrate; axial area narrow, central area small or lacking; striae slightly radiate. Length 28-35 µm, breadth 7.5-9.5 µm, striae 12 to 20 in 10 µm. Habitat: pH 7.0-8.0, air temperature 14-17°C, water temperature 3-20°C, altitude 4400-5500 m. Present in samples: 118b, 125, 134. Distributed in Tibet, Qinghai and Guizhou Province (Li *et al.*, 2002; Li *et al.*, 2003).

***Cymbella excisa* var. *procera* Krammer (Fig. 34)**

Krammer (2002: 28, pl. 9, figs 1-7).

Differs from the nominate variety by the shape of its valve. Length 26-32 µm, breadth 8-9 µm, striae 8 to 14 in 10 µm. Habitat: pH 8.0, air temperature 16-17°C, water temperature 7-20°C, altitude 4570-5000 m. Present in samples: 123, 125. **This is a new record for China.**

Cymbella excisiformis* Krammer*(Fig. 35)**

Krammer (2002: 31, pl. 13, figs 1-8).

Valves dorsi-ventral, linear-lanceolate with sub-rostrate to capitate poles, dorsal margin distinctly convex, ventral margin slightly convex to straight; axial area narrow, central area small; striae slightly radiate, becoming more radiate towards the poles. Length 28-43 μm , breadth 8-9.5 μm , striae 8 to 16 in 10 μm . Habitats: pH 5.0-10, air temperature 13.5-30°C, water temperature 3-23°C, altitude 1668-5500 m. Present in samples: 116a, 116b, 116c, 118b, 101, 109, 110, 114a, 114b, 114c, 121, 123, 124, 125, 127, 129, 130, 131, 132, 133, 134, 135a, 135b, 137, 139. **This is a new record for China.**

Cymbella halophila* Krammer*(Figs 36, 37)**

Krammer (2002: 120, pl. 135, figs 1-6).

Valves dorsi-ventral with broadly convex dorsal margin and slightly concave ventral margin with tumid centre, poles broadly truncate or rounded; axial area linear, broad, central area lanceolate; striae radiate. Length 188-200 μm , breadth 37-41 μm , striae 7 to 11 in 10 μm . Habitat: pH 8.0, air temperature 20°C, water temperature 16°C, altitude 4950 m. Present in sample: 114c. **This is a new record for China.**

Cymbella hantzschiana* Krammer*(Fig. 38)**

Krammer (2002: 47, pl. 28, figs 1-19).

Valves strongly dorsi-ventral with strongly convex dorsal margin and slightly convex to straight ventral margin with tumid centre; poles rounded; axial area narrow, linear, central area small or absent; striae slightly radiate, becoming more radiate towards the poles. Length 32-62 μm , breadth 9-11.5 μm , striae 8 to 14 in 10 μm . Habitat: pH 5.5-8.5, air temperature 13.5-24°C, water temperature 10-23°C, altitude 4280-4950 m. Present in samples: 116b, 130, 132, 133, 134. **This is a new record for China.**

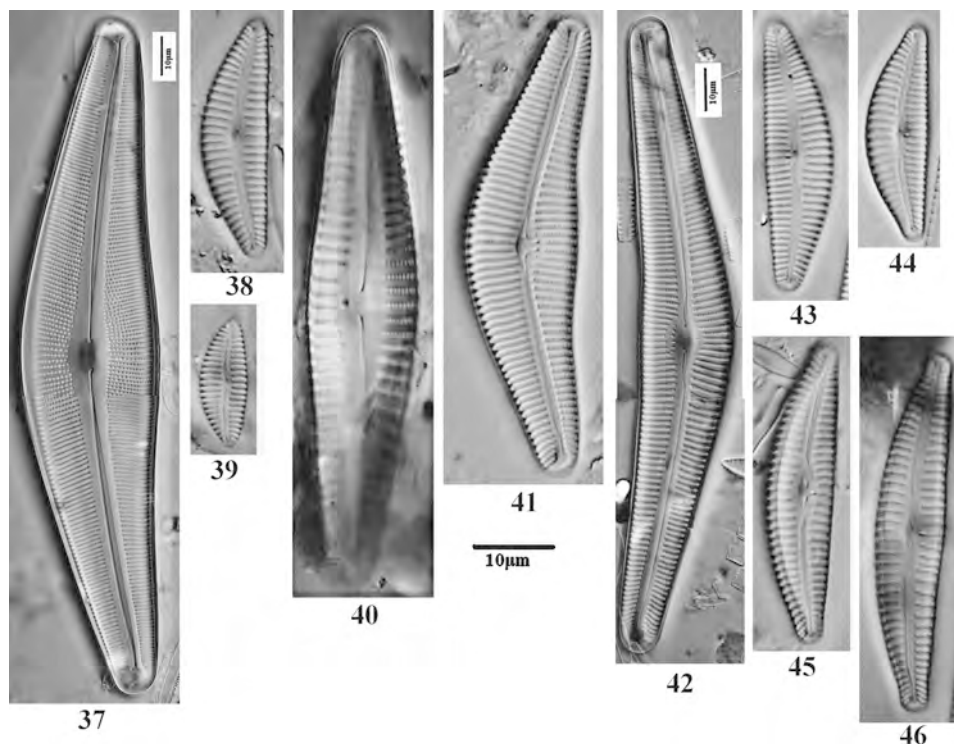
Cymbella hustedtii* Krasske*(Fig. 39)**

Krammer (2002: 137, pl. 160, figs 7-27).

Valves dorsi-ventral with shallow-convex ventral margin and arched dorsal margin; poles bluntly rounded; axial area narrow, central area lacking; striae parallel, becoming radiate toward the pole. Length 17-22 μm , breadth 6-7.5 μm , striae 8 to 16 in 10 μm . Habitat: pH 6.0-8.5, air temperature 13.5-23°C, water temperature 13-20°C, altitude 2380-5000 m. Present in samples: 110, 125, 127, 129. Distributed in Jilin Province, Tibet, Yunnan Province, Hunan Province and Guizhou Province (Liu, 1982; Li, 1983; Gao, 1987; Wei *et al.*, 1994; Zhu & Chen, 1994).

Cymbella japonica* Reichelt*(Fig. 40)**Schmidt *et al.* (1931: 373, figs 29-31), Haraguchi (1997: 229, fig. 11).

Valves rhomboid-lanceolate; poles narrowly rounded; axial area wide, lanceolate, central area small or lacking; striae slightly radiate, becoming more radiate towards the poles. Length 65-78 μm , breadth 13-15.5 μm , striae 7 to 12 in 10 μm . Habitat: pH 7.0, air temperature 27°C, water temperature 17°C, altitude 2350 m. Present in sample: 137. Distributed in Tibet, Hunan and Guizhou Provinces (Zhu & Chen, 1989, 1994 & 2000).



Figs 37-46. **37.** *Cymbella halophila* Krammer. **38.** *Cymbella hantzschiana* Krammer. **39.** *Cymella hustedtii* Krasske. **40.** *Cymbella japonica* Reichelt. **41.** *Cymbella neocistula* Krammer. **42.** *Cymbella neocistula* var. *islandica* Krammer. **43, 44.** *Cymbella parva* (W. Sm.) Cl. **45, 46.** *Cymbella perparva* Krammer.

***Cymbella neocistula* Krammer (Fig. 41)**

Krammer (2002: 94, pl. 90, figs 1-8).

Valves dorsi-ventral with broadly convex dorsal margin and slightly concave ventral margin with tumid centre; poles broadly truncate or rounded; axial area narrow, linear, central area small, somewhat rounded; isolated stigmata (2-7) in ventral portion of central area; striae radiate. Length 50-90 µm, breadth 13-16 µm, striae 7 to 14 in 10 µm. Habitat: pH 5.5-10, air temperature 12-27°C, water temperature 3-25°C, altitude 1668-5500 m. Present in samples: 116b, 118b, 109, 114a, 114b, 114c, 121, 123, 124, 125, 127, 129, 130, 131, 132, 133, 134, 138. Distributed widely in China.

***Cymbella neocistula* var. *islandica* Krammer (Fig. 42)**

Krammer (2002: 95, pl. 93, figs 1-5).

Differs from the nominate variety in its larger breadth and denser striae. Length 85-115 µm, breadth 20-25 µm, striae 9 to 11 in 10 µm. Habitat: pH 5.5-10, air temperature 12-27°C, water temperature 10-23°C, altitude 1668-5000 m. Present in samples: 116a, 116b, 116c, 109, 110, 114a, 114b, 114c, 121, 123, 124, 125, 127, 129, 130, 131, 132, 133, 134, 137. **This is a new record for China.**

Cymbella parva* (W. Sm.) Kirchner*(Figs 43, 44)**

Cleve-Euler (1955: 158, fig. 1244).

Valves moderately dorsi-ventral with slightly concave ventral margin, slightly tumid in the centre; poles bluntly rounded; axial area linear, arched, central area small; striae radiate. Length 26-36 μm , breadth 7-9 μm , striae 10 to 18 in 10 μm . Habitat: pH 8.0-8.5, air temperature 12-16°C, water temperature 15-21°C, altitude 5000-5100 m. Present in samples: 121, 124. Distributed in Tibet, Sichuan, Qinghai, Shanxi, Hunan and Guizhou Provinces (Zhu & Chen, 1989, 1994 & 2000; Bao *et al.*, 1986; Gao, 1987; Mereschkowsky, 1906).

Cymbella perparva* Krammer*(Figs 45, 46)**

Krammer (2002: 38, pl. 18, figs 1-15).

Valves dorsi-ventral with convex dorsal margin and slightly convex to straight ventral margin; poles rostrate to sub-capitate; axial area narrow, central area small or absent; isolated stigma at end of ventral striae at central area; striae slightly radiate, becoming more radiate towards the poles. Length 40-51 μm , breadth 8.5-10.5 μm , striae 10 to 14 in 10 μm . Habitat: pH 8.0-10, air temperature 16-20°C, water temperature 16-21°C, altitude 4570-5000 m. Present in sample: 116b, 114c, 124, 125, 127, 129, 130. **This is a new record for China.**

Cymbella pervarians* Krammer*(Figs 47, 48)**

Krammer (2002: 58, pl. 41, figs 1-12).

Valves moderately dorsi-ventral with slightly concave ventral margin, slightly tumid in the centre; poles bluntly rounded; axial area linear, arched, central area small; striae radiate. Length 50-57 μm , breadth 10-11.5 μm , striae 12 to 18 in 10 μm . Habitat: pH 8.0-8.5, air temperature 12-16°C, water temperature 15-21°C, altitude 5000-5100 m. Present in samples: 121, 124. **This is a new record for China.**

Cymbella stigmaphora* Østrup*(Fig. 49)**

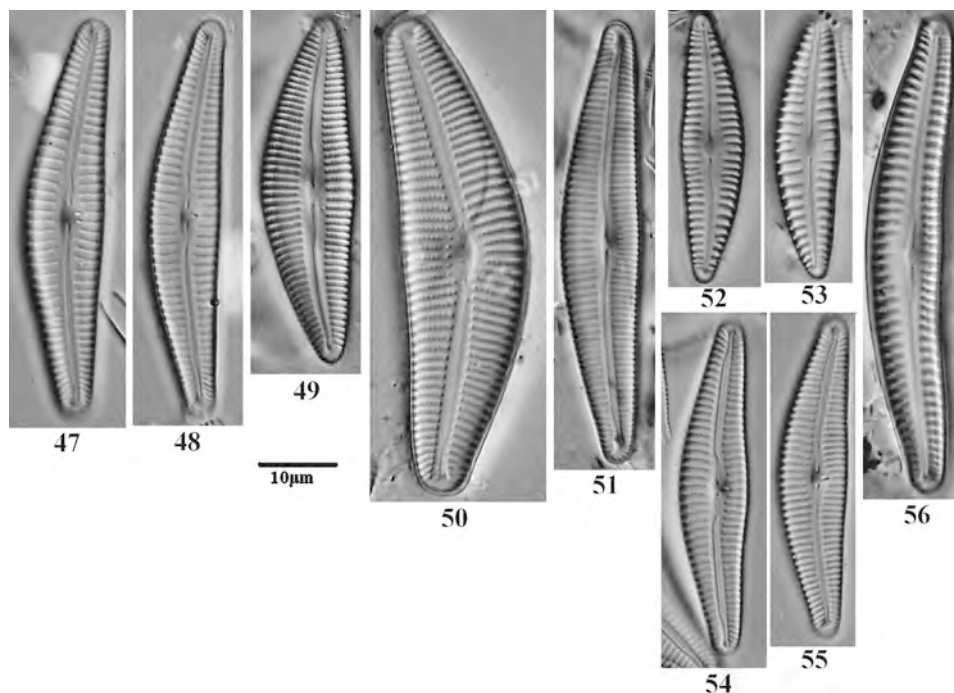
Krammer. (2002: 135, pl. 154, figs 18-23).

Valves slightly dorsi-ventral, rhombic with smoothly arched dorsal margin and slightly convex ventral margin, gibbous at mid-valve, axial area moderately wide, central area absent; raphe distinctly lateral, becoming slightly reverse-lateral, distant from proximal poles; striae slightly radiate in the middle portion, radiate towards the poles. Length 45-55 μm , breadth 12-14 μm , striae 7 to 10 in 10 μm . Habitat: pH 7.0, air temperature 20°C, water temperature 15°C, altitude 4400 m. Present in sample: 134. **This is a new record for China.**

Cymbella subcistula* Krammer*(Fig. 50)**

Krammer (2002: 93, pl. 84, figs 5-9).

Valves strongly dorsi-ventral with convex dorsal margin and nearly straight ventral margin, slightly tumid centre; poles narrowly rounded; axial area narrow, central area small, round; striae slightly radiate at the centre, becoming more distinctly radiate toward poles. Length 48-60 μm , breadth 14-17 μm , striae 8 to 15 in 10 μm . Habitat: pH 6.5-8.5, air temperature 16-22°C, water temperature 7-20°C, altitude 1668-5000 m. Present in sample: 109, 123, 125, 131. **This is a new record for China.**



Figs 47-56. **47, 48.** *Cymbella pervarians* Krammer. **49.** *Cymbella stigmaphora* Østrup. **50.** *Cymbella subcistula* Krammer. **51.** *Cymbella subhelvetica* Krammer. **52, 53.** *Cymbella subleptoceros* (Ehrenberg) Kützing. **54, 55.** *Cymbella vulgata* Krammer. **56.** *Cymbella* sp.1.

***Cymbella subhelvetica* Krammer (Fig. 51)**

Krammer (2002: 151, pl. 176, figs 1-13).

Valves strongly dorsi-ventral with convex dorsal margin and slightly convex to straight ventral margin with tumid centre; poles narrowly rounded; axial area narrow, central area small or absent; striae slightly radiate, becoming parallel towards the poles. Length 45-64 µm, breadth 9-12 µm, striae 9 to 14 in 10 µm. Habitat: pH 8.5-10, air temperature 13.5°C, water temperature 14°C, altitude 4750 m. Present in samples: 129, 130. **This is a new record for China.**

***Cymbella subleptoceros* Krammer (Figs 52, 53)**

Krammer (2002: 133, pl. 154, figs 2-17).

Valves moderately dorsi-ventral with convex dorsal margin and slightly convex ventral margin, slightly tumid in the centre, poles bluntly rounded; axial area linear, central area indistinct or lacking; striae radiate. Length 30-45 µm, breadth 7-9 µm, striae 8 to 11 in 10 µm. Habitat: pH 5.0-10, air temperature 13.5-24°C, water temperature 7-23°C, altitude 1668-4950 m. Present in samples: 101, 109, 110, 114a, 114b, 114c, 123, 125, 129, 130, 131, 132, 133, 135a. **This is a new record for China.**

Cymbella vulgata* Krammer*(Figs 54, 55)**

Krammer (2002: 55, pl. 36, figs 1-14).

Valves strongly dorsi-ventral with convex dorsal margin and strongly concave ventral margin with slightly tumid centre; poles narrowly rounded; axial area narrow, central area small, round; striae slightly radiate at the centre, becoming more distinctly radiate toward the poles. Length 45-58 μm , breadth 9.5-11 μm , striae 8 to 15 in 10 μm . Habitat: pH 6.0-8.5, air temperature 16-20°C, water temperature 7-23°C, altitude 1668-5100 m. Present in sample: 109, 114a, 114b, 114c, 121, 123, 124, 125, 132, 135a. **This is a new record for China.**

Cymbella* sp. 1*(Figs 56-58)**

Valves dorsi-ventral, narrow-lanceolate with shallow-convex dorsal margin and slightly convex or nearly straight ventral margin; axial area narrow, central area small or lacking; striae radiate. Length 58-84 μm , breadth 9.5-11.5 μm , striae 8 to 14 in 10 μm . Habitat: pH 8.0, air temperature 12°C, water temperature 15°C, altitude 5100 m. Present in sample: 121.

Cymbella* sp. 2*(Figs 59, 60)**

Valves moderately dorsi-ventral, broadly lanceolate, dorsal margin convex and ventral margin concave; poles broadly rounded; axial area moderately wide, 1/4-1/3 of the valve breadth, central area moderately large, rounded; striae slightly radiate, becoming strongly radiate near the poles. Length 55-60 μm , breadth 9-10.5 μm , striae 6 to 10 in 10 μm . Habitat: pH 8.5, air temperature 16°C, water temperature 21°C, altitude 5000 m. Present in sample: 124.

Cymbella* sp. 3*(Figs 61, 62)**

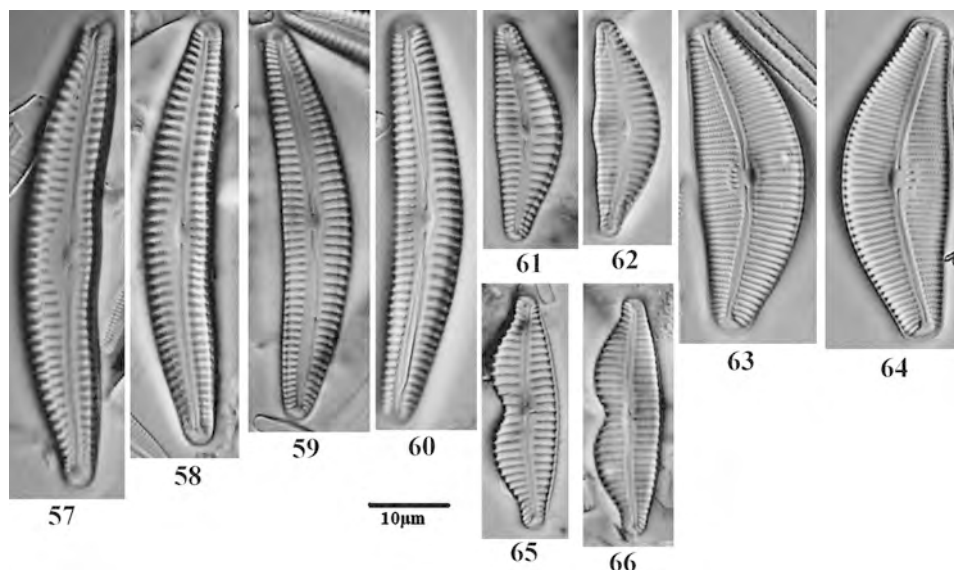
Valves dorsi-ventral with arched dorsal margin and nearly straight ventral margin with slightly tumid mid-valve; poles narrowly rounded; axial area narrow, central area absent; striae slightly radiate, becoming more radiate towards the poles. Length 26.5-40 μm , breadth 8-10 μm , striae 10 to 16 in 10 μm . Habitat: pH 8.0, air temperature 20°C, water temperature 16°C, altitude 4950 m. Present in sample: 114a.

Cymbella* sp. 4*(Figs 63, 64)**

Valves strongly dorsi-ventral, dorsal margin convex and ventral margin nearly straight with slightly tumid centre; poles broadly rounded; axial area narrow, central area small, rounded; 4 isolated stigmata in ventral portion of central area; striae slightly radiate. Length 47-55 μm , breadth 16-18 μm , striae 9 to 13 in 10 μm . Habitat: pH 8.5-10, air temperature 13.5-18°C, water temperature 14-23°C, altitude 4750 m. Present in samples: 129, 130, 132.

Cymbella* sp. 5*(Figs 65, 66)**

Valves moderately dorsi-ventral, broadly lanceolate, dorsal margin convex and strongly excise in the centre, ventral margin slightly convex; poles subrostrate and narrowly rounded; axial area narrow, central area indistinct; one isolated stigma at end of middle stria on ventral side; striae slightly radiate, becoming strongly radiate near poles. Length 30-34 μm , breadth 8-9.5 μm , striae 9 to 14 in 10 μm . Habitat: pH 8.0, air temperature 16-17°C, water temperature 7-20°C, altitude 4570-5000 m. Present in samples: 123, 125.



Figs 57-66. **57, 58.** *Cymbella* sp. 1. **59, 60.** *Cymbella* sp. 2. **61, 62.** *Cymbella* sp. 3. **63, 64.** *Cymbella* sp. 4. **65, 66.** *Cymbella* sp. 5.

***Cymbella* sp. 6 (Figs 67, 68)**

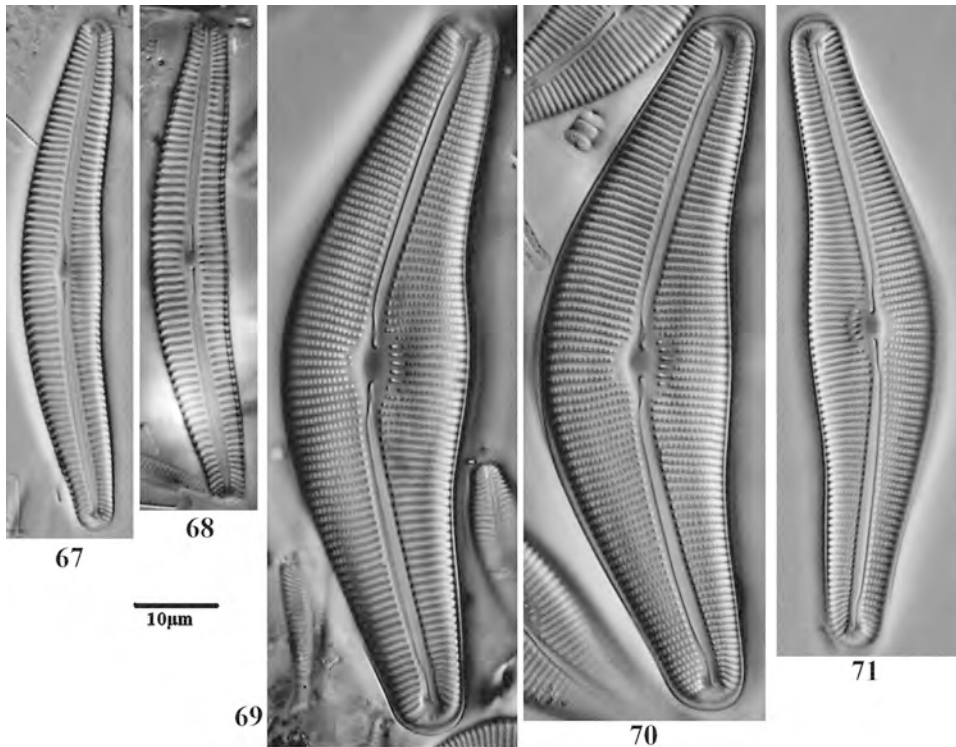
Valves moderately dorsi-ventral with arched dorsal and ventral margin; poles bluntly rounded; axial area linear, arched; central area small or absent; striae slightly radiate. Length 60-86 µm, breadth 8-8.5 µm, striae 10 to 15 in 10 µm. Habitat: pH 10, air temperature 13.5°C, water temperature 14°C, altitude 4750 m. Present in sample: 129.

***Cymbella* sp. 7 (Figs 69, 70)**

Valves strongly dorsi-ventral, dorsal margin convex and ventral margin concave with tumid centre; poles broadly rounded; axial area narrow, central area moderately large, rounded; isolated stigmata (5-6) in ventral portion of central area; striae radiate. Length 93-97 µm, breadth 20-25 µm, striae 8 to 12 in 10 µm. Habitat: pH 10, air temperature 13.5°C, water temperature 14°C, altitude 4750 m. Present in sample: 129.

***Cymbella* sp. 8 (Figs 70-74)**

Valves moderately dorsi-ventral, dorsal margin convex and ventral margin concave or nearly straight with slightly tumid centre; poles broadly rounded, axial area narrow, central area moderately large, rounded, 1/5-1/4 of the valve breadth; isolated stigmata (4-5) in ventral portion of central area; striae slightly radiate or parallel, becoming radiate near the poles. Length 57-85 µm, breadth 17-19 µm, striae 9 to 12 in 10 µm. Habitat: pH 8.0-10, air temperature 13.5-20°C, water temperature 3-23°C, altitude 4750-5500 m. Present in samples: 114a, 116a, 118b, 129, 130, 132.



Figs 67-71. **67, 68.** *Cymbella* sp. 6. **69, 70.** *Cymbella* sp. 7. **70, 71.** *Cymbella* sp. 8.

Encyonema Kütz

Encyonema auerswaldii Rabenh.

(Fig. 75)

Krammer (1997a: 117, pl. 67, figs 9-14).

Valves dorsi-ventral, elliptic to lanceolate with arched dorsal margin and smoothly convex, or slightly tumid ventral margin; poles broadly blunt; axial area linear, central area small; striae slightly radiate. Length 25-32 μm , breadth 9-10 μm , striae 8 to 14 in 10 μm . Habitat: pH 6.0-8.5, air temperature 13-30°C, water temperature 3-18°C, altitude 2350-5500 m. Present in samples: 118a, 139. Distributed in Tibet (Zhu & Chen, 2000).

Encyonema dubium Krammer

(Figs 76, 77)

Krammer (1997b: 29, pl. 109, figs 8-16).

Valves strongly dorsi-ventral, lanceolate with arched dorsal margin and nearly straight ventral margin; poles rounded; axial area narrow, central area small or absent; striae slightly radiate. Length 29-36 μm , breadth 9-9.5 μm , striae 9 to 14 in 10 μm . Habitat: pH 5.0-6.0, air temperature 16.5-28°C, water temperature 13-18°C, altitude 1750-2750 m. Present in samples: 110, 135b, 136. **This is a new record for China.**

***Encyonema fogedii* Krammer (Figs 78, 79)**

Krammer (1997a: 104, pl. 26, figs 1-12).

Valves dorsi-ventral, semi-lanceolate with arched dorsal margin and nearly straight ventral margin; poles narrowly rounded and ventrally bent; axial area moderately narrow, central area small or absent; striae slightly radiate. Length 13-18 μm , breadth 4-5 μm , striae 9 to 14 in 10 μm . Habitat: pH 6.5-8.5, air temperature 12-22°C, water temperature 10-15°C, altitude 1668-5100 m. Present in samples: 109, 121, 131, 134. **This is a new record for China.**

***Encyonema hustedtii* Krammer (Fig. 80)**

Krammer (1997a: 86, pl. 42, figs 6-11).

Valves strongly dorsi-ventral, lanceolate-elliptical with strongly arched dorsal margin and slightly convex ventral margin; poles rounded; axial area moderately narrow, lanceolate, central area small or absent; striae radiate. Length 42-48 μm , breadth 9-11 μm , striae 7 to 11 in 10 μm . Habitat: pH 8.0, air temperature 12°C, water temperature 15°C, altitude 5100 m. Present in sample: 123. **This is a new record for China.**

***Encyonema jemtlandicum* Krammer (Fig. 81)**

Krammer (1997a: 82, pl. 35, figs 1-9).

Valves dorsi-ventral, semi-lanceolate with arched dorsal margin and almost straight ventral margin; poles rounded; axial area moderately narrow, central area small or absent; striae slightly radiate. Length 38-46 μm , breadth 8-9.5 μm , striae 8 to 14 in 10 μm . Habitat: pH 8.0-8.5, air temperature 17-18°C, water temperature 20-23°C, altitude 4570-4750 m. Present in samples: 125, 132. **This is a new record for China.**

***Encyonema jemtlandicum* var. *venezolanum* Krammer (Fig. 82)**

Krammer (1997a: 83, pl. 14, figs 1-5).

Differ from the nominate variety by a wider central area. Length 28-35 μm , breadth 8-9 μm , striae 9 to 14 in 10 μm . Habitat: pH 6.0-8.5, air temperature 17-23°C, water temperature 11-23°C, altitude 1668-4750 m. Present in samples: 109, 110, 125, 132. **This is a new record for China.**

***Encyonema jolmolungmensis* (Jao et Lee) Li, nov. comb. (Figs 83, 84)**

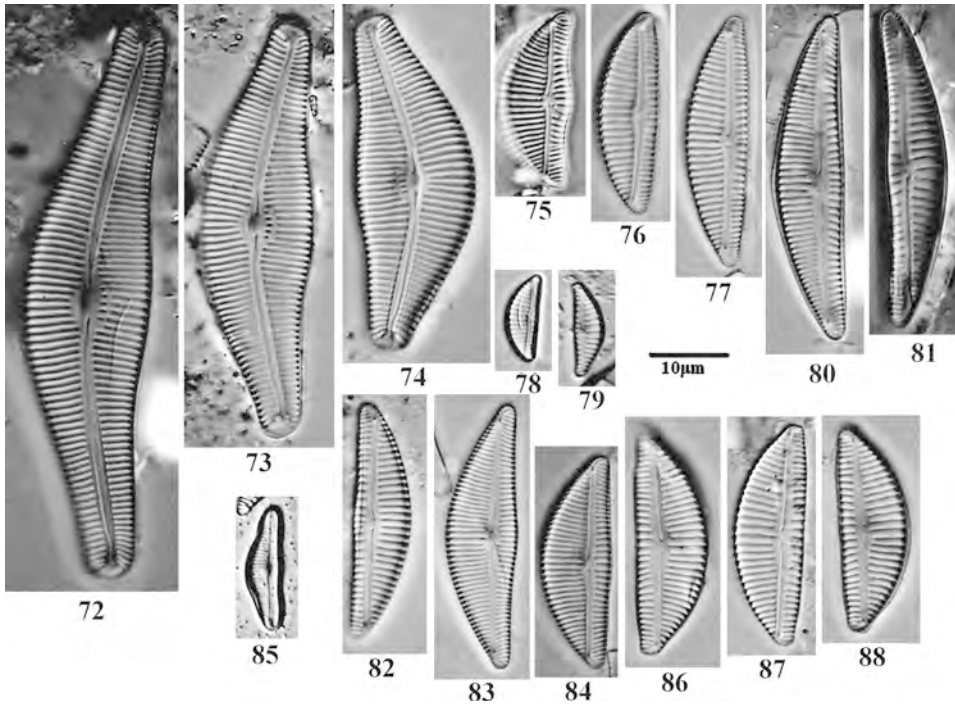
Basionym: *Cymbella jolmolungmensis* Jao et Lee in Jao et al. (1974: 121, pl. II, fig. 2).

Valves strongly dorsi-ventral, cymbiform with strongly arched dorsal margin and nearly straight ventral margin, tumid in the centre; poles narrowly rounded; axial area narrow, central area small; striae radiate. Length 30-38 μm , breadth 9.5-11 μm , striae 12 to 18 in 10 μm . Habitat: pH 8.5-10.0, air temperature 13.5°C, water temperature 14°C, altitude 4750 m. Present in samples: 129, 130.

***Encyonema jordanii* (Grun.) F.W. Mills (Fig. 85)**

Krammer (1997b: 65, pl. 127, figs 1-9).

Valves strongly dorsi-ventral, lanceolate-elliptical with strongly arched dorsal margin and slightly convex ventral margin; poles capitate, rounded and ventrally bent; axial area moderately narrow, central area small or absent; striae radiate. Length 15-18 μm , breadth 5-6 μm , striae 15 to 21 in 10 μm . Habitat: pH 8.0, air temperature 12°C, water temperature 15°C, altitude 5100 m. Present in sample: 121. **This is a new record for China.**



Figs 72-88. **72-74.** *Cymbella* sp. 8. **75.** *Encyonema auerswaldii* Rabenh. **76, 77.** *Encyonema dubium* Krammer. **78, 79.** *Encyonema fagedii* Krammer. **80.** *Encyonema hustedtii* Krammer. **81.** *Encyonema jemtlandicum* Krammer. **82.** *Encyonema jemtlandicum* var. *venezolanum* Krammer. **83, 84.** *Encyonema jolmolungmensis* (Jao et Lee) Li, nov. comb. **85.** *Encyonema jordanii* (Grunow) Mills. **86-88.** *Encyonema lange-bertalotii* Krammer.

***Encyonema lange-bertalotii* Krammer**

(Figs 86-88)

Krammer (1997a: 96, pl. 5, figs 1-16).

Valves strongly dorsi-ventral, semi-lanceolate-elliptical with convex dorsal margin and straight ventral margin; axial area narrow, linear, central area absent; striae radiate. Length 28-37 μm , breadth 9-11 μm , striae 8 to 16 in 10 μm . Habitat: pH 8.0, air temperature 20°C, water temperature 16°C, altitude 4950 m. Present in samples: 114a, 114b, 114c. **This is a new record for China.**

***Encyonema lange-bertalotii* var. *inarensis* Krammer**

(Fig. 89)

Krammer (1997a: 97, pl. 29, fig. 14).

Valves dorsi-ventral, semi-lanceolate with arched dorsal margin and nearly straight ventral margin; poles rounded and ventrally bent; axial area moderately narrow, central area small or absent; striae slightly radiate. Length 25-35 μm , breadth 8-10 μm , striae 9 to 14 in 10 μm . Habitat: pH 5.0-6.5, air temperature 19-24°C, water temperature 11-16°C, altitude 1668 m. Present in samples: 101, 109. **This is a new record for China.**

***Encyonema lange-bertalotii* var. *obscuriformis* Krammer (Figs 90-92)**

Krammer (1997a: 97, pl. 27, figs 13-16).

Valves dorsi-ventral, semi-lanceolate with arched dorsal margin and nearly straight ventral margin; poles rounded, sub-capitate and ventrally bent; axial area moderately narrow, central area small or absent; striae slightly radiate. Length 18-24 μm , breadth 7-8.5 μm , striae 12 to 20 in 10 μm . Habitat: pH 5.0-8.5, air temperature 13.5-24°C, water temperature 3-20°C, altitude 1668-5500 m. Present in samples: 116a, 116b, 116c, 118a, 118b, 101, 109, 114a, 114c, 125, 127, 130, 134, 135a. **This is a new record for China.**

***Encyonema lunatum* (W. Smith) Van Heurck (Figs 93,94)**

Krammer (1997a: 150, pl. 83, figs 8-12).

Valves dorsi-ventral, lanceolate with arched dorsal and straight ventral margins; poles rounded; axial area narrow, linear, central area slightly widening; striae parallel or slightly radiate. Length 30-48 μm , breadth 5-7 μm , striae 7 to 16 in 10 μm near the poles. Habitat: pH 8.0, air temperature 20°C, water temperature 16°C, altitude 4950 m. Present in sample: 114c. Distributed in Heilongjiang Province (Fan *et al.*, 1998).

***Encyonema minutum* (Hilse in Rabenh.) D. G. Mann (Figs 95-97)**

Krammer (1997a: 53, pl. 25, figs 1-19).

Valves dorsi-ventral with convex dorsal margin and straight ventral margin; poles slightly produced; axial area linear, central area small; striae slightly radiate to parallel. Length 18-24 μm , breadth 6-8 μm , striae 12 to 22 in 10 μm . Habitat: pH 5.0-10, air temperature 12-30°C, water temperature 3-23°C, altitude 1668-5500 m. Present in samples: 101, 109, 121. Distributed in northeast plain and Qinghai Province (Bao *et al.*, 1992; Li *et al.*, 2002) and as fossil in the Jianhan Plain in China (Shi, 1997).

***Encyonema neogracile* Krammer (Figs 98-100)**

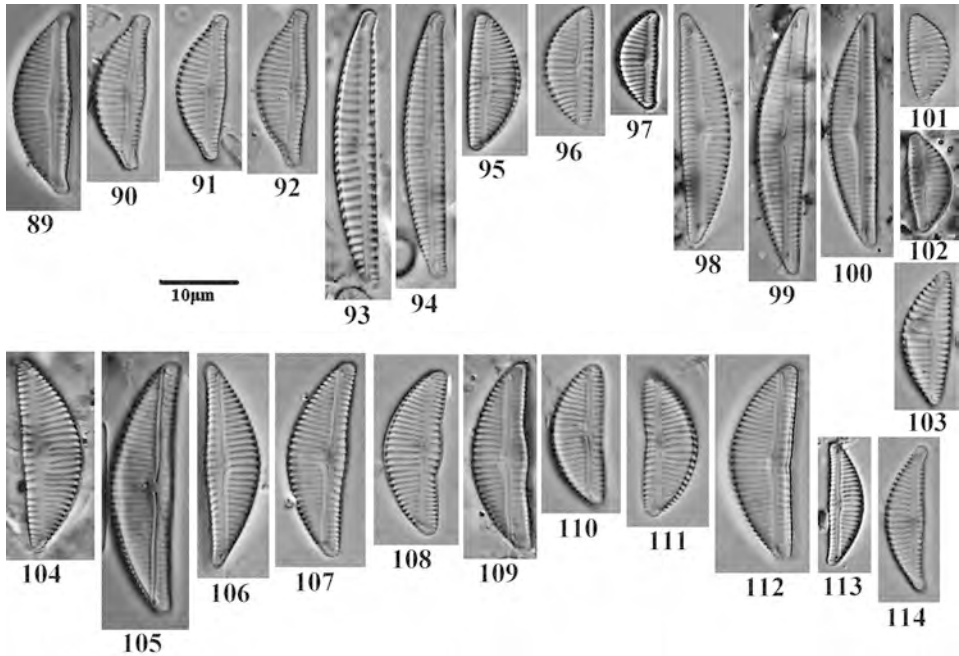
Krammer (1997a: 142, pl. 92, figs 1-10).

Valves dorsi-ventral, lanceolate with arched dorsal and straight ventral margin; poles rounded; axial area narrow, linear, central area widening slightly; striae parallel or slightly radiate. Length 39-52 μm , breadth 6.5-8 μm , striae 9 to 18 in 10 μm near the poles. Habitat: pH 5.0-8.5, air temperature 16-30°C, water temperature 11-25°C, altitude 1668-5000 m. Present in samples: 109, 110, 136, 114c, 132, 135a, 137, 138, 139. Distributed in Heilongjiang and Tibet (Fan *et al.*, 1998; Zhu & Chen, 2000).

***Encyonema parvum* Krammer (Figs 101-103)**

Krammer (1997b: 13, pl. 191, figs 10-15).

Valves strongly dorsi-ventral, semi-lanceolate with strongly arched dorsal margin and slightly convex ventral margin; poles narrowly rounded; axial area narrow, central area small or absent; striae radiate. Length 12-20 μm , breadth 6-8 μm , striae 10 to 15 in 10 μm . Habitat: pH 5.0-6.5, air temperature 19-24°C, water temperature 11-16°C, altitude 1668 m. Present in samples: 109, 110, 123, 134. **This is a new record for China.**



Figs 89-114. **89.** *Encyonema lange-bertalotii* var. *inarenis* Krammer. **90-92.** *Encyonema lange-bertalotii* var. *obscuriformis* Krammer. **93, 94.** *Encyonema lunatum* (W. Smith) Van Heurck. **95-97.** *Encyonema minutum* (Hilse in Rabenh.) D.G.Mann. **98-100.** *Encyonema neogracile* Krammer. **101-103.** *Encyonema parvum* Krammer. **104.** *Encyonema procerum* Krammer. **105-107.** *Encyonema silesiacum* (Bleisch ex Rabenh.) D.G.Mann. **108, 109.** *Encyonema silesiacum* var. *altensis* Krammer. **110-112.** *Encyonema silesiacum* var. *excisa* Krammer. **113, 114.** *Encyonema ventricosum* (Agardh) Grunow.

***Encyonema procerum* Krammer**

(Fig. 104)

Krammer (1997a: 95, pl. 32, figs 9-19).

Valves strongly dorsi-ventral, semi-lanceolate with strongly arched dorsal margin and nearly straight ventral margin; poles narrowly rounded; axial area narrow, central area small or absent; striae slightly radiate. Length 28 μm , breadth 8.5 μm , striae 10 to 15 in 10 μm . Habitat: pH 6.5, air temperature 19°C, water temperature 11°C, altitude 1668 m. Present in sample: 109. **This is a new record for China.**

***Encyonema silesiacum* (Bleisch ex Rabenh.) D. G. Mann**

(Figs 105-107)

Krammer (1997a: 75, pl. 4, figs 1-16).

Differs from the nominate variety by larger size and a more distinctly isolated stigma. Length 23-42 μm , breadth 7.5-9 μm , striae 8 to 14 in 10 μm . Habitat: pH 5.0-10, air temperature 12-30°C, water temperature 3-25°C, altitude 1668-5500 m. Present in samples: 116a, 118a, 118b, 101, 109, 110, 121, 123, 125, 127, 129, 130, 131, 132, 133, 134, 138, 139. Distributed in northeast plain, Qinghai and Hubei Provinces (Fan & Bao, 1991; Qi & Xie, 1985; Li *et al.*, 2002).

***Encyonema silesiacum* var. *altensis* Krammer (Figs 108, 109)**

Krammer (1997a: 75, pl. 9, figs 9-19).

Valves dorsi-ventral with arched dorsal margin and nearly straight ventral margin, bulbous at the centre; poles obtusely rounded; axial area narrow, central area small; striae radiate. Length 23-30 μm , breadth 7-8.5 μm , striae 10 to 18 in 10 μm . Habitat: pH 6.5-8.5, air temperature 13.5-27°C, water temperature 7-20°C, altitude 1668-5000 m. Present in samples: 109, 123, 125, 130, 137. **This is a new record for China.**

***Encyonema silesiacum* var. *excisa* Krammer (Figs 110-112)**

Krammer (1997a: 76, pl. 11, figs 13, 14).

Valves dorsi-ventral with arched dorsal margin and nearly straight ventral margin; poles obtusely rounded; axial area narrow, central area small; striae radiate; an isolate stigma on the dorsal side of central area. Length 25-35 μm , breadth 8-10 μm , striae 10 to 18 in 10 μm . Habitat: pH 6.5-8.5, air temperature 13.5-19°C, water temperature 11-14°C, altitude 1668-4750 m. Present in samples: 109, 130. **This is a new record for China.**

***Encyonema ventricosum* (Agardh) Grun. in A. Schmidt (Figs 113, 114)**

Krammer (1997a: 98, pl. 6, figs 5-17).

Valves dorsi-ventral, semi-lanceolate with strongly convex dorsal margin and straight ventral margin, slightly tumid in the centre; poles slightly produced; axial area linear, central area small; striae slightly radiate to parallel. Length 18-24 μm , breadth 4.5-6 μm , striae 12 to 22 in 10 μm . Habitat: pH 5.0-10, air temperature 12-30°C, water temperature 3-23°C, altitude 1668-5500 m. Present in samples: 116a, 116b, 118a, 118b, 119, 101, 109, 110, 114a, 114b, 114c, 121, 123, 124, 125, 127, 129, 130, 131, 132, 133, 134, 135a, 135b, 137, 139. Distributed in Sichuan, Shanxi, Guizhou Province and Tibet (Zhong *et al.*, 1986; Gao, 1987; Zhu & Chen, 1994, 2000).

***Encyonopsis* Krammer**

***Encyonopsis cesatii* (Rabenh.) Krammer (Figs 115-118)**

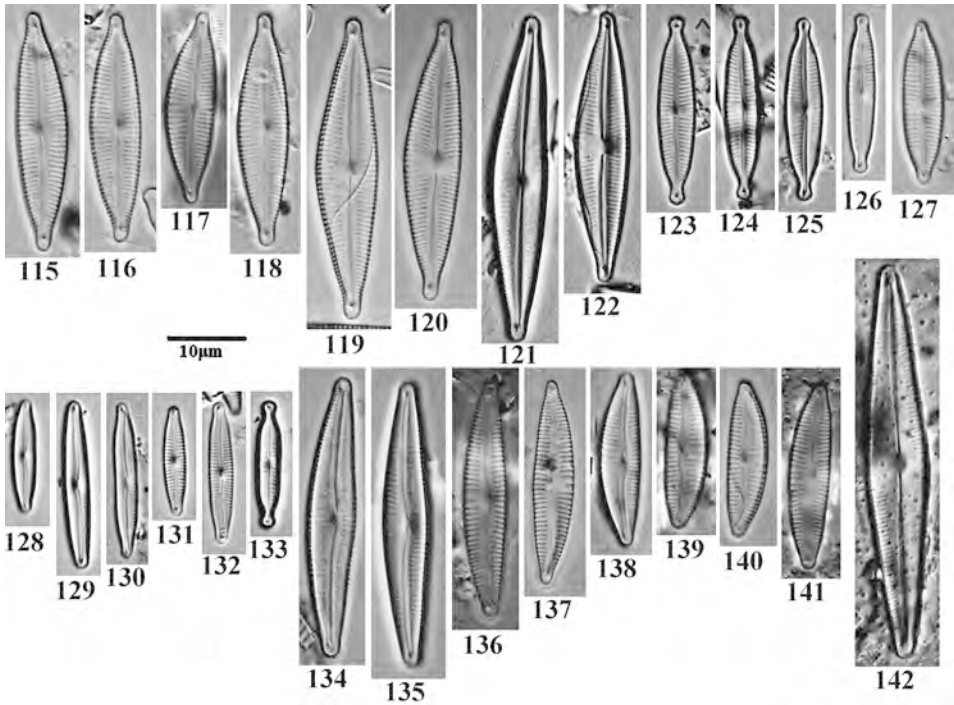
Krammer (1997b: 152, pl. 185, figs 1-6).

Valves slightly dorsi-ventral, linear-lanceolate; poles quite narrow; axial area narrow, central area small; striae parallel or slightly radiate at the centre, becoming distinctly radiate toward the poles. Length 30-37 μm , breadth 6-7.5 μm , striae 16 to 24 in 10 μm . Habitat: pH 5.5-8.5, air temperature 12-30°C, water temperature 3-23°C, altitude 1668-5500 m. Present in samples: 116b, 116c, 118b, 109, 114a, 114b, 114c, 121, 123, 124, 125, 127, 130, 131, 132, 133, 134, 137, 139. Distributed in Tibet, Sichuan, Qinghai, Hunan and Guizhou (Zhu & Chen, 1989, 1994 and 2000; Bao *et al.*, 1986; Li *et al.*, 2002).

***Encyonopsis cesatiformis* Krammer (Figs 119-122)**

Krammer (1997b: 156, pl. 178, figs 7-10).

Valves slightly dorsi-ventral, linear-lanceolate; poles quite narrow; axial area narrow, central area large, 1/3 of the valve breadth; striae slightly radiate at the centre, becoming distinctly radiate toward the poles. Length 30-50 μm , breadth 7-9.5 μm , striae 15 to 22 in 10 μm . Habitat: pH 8.0, air temperature 12°C, water temperature 15°C, altitude 5100 m. Present in sample: 121. **This is a new record for China.**



Figs 115-142. **115-118.** *Encyonopsis cesatii* (Rabenhorst) Krammer. **119-122.** *Encyonopsis cesatifformis* Krammer. **123-125.** *Encyonopsis falaisensis* (Grunow) Krammer. **126.** *Encyonopsis microcephala* (Grunow) Krammer. **127.** *Encyonopsis neoamphioxys* Krammer. **128-132.** *Encyonopsis perborealis* Krammer. **133.** *Encyonopsis tiroliana* Krammer et Lange-Bert. **134, 135.** *Delicata delicatula* (Kützing) Krammer. **136, 137.** *Delicata sinensis* Krammer et Metzeltin. **138.** *Delicata sparsistriata* Krammer. **139-141.** *Delicata* sp. 1. **142.** *Delicata* sp. 2.

***Encyonopsis falaisensis* (Grun.) Krammer**

(Figs 123-125)

Krammer (1997b: 116, pl. 161, figs 3-5).

Valves slightly dorsi-ventral, linear-lanceolate with convex dorsal and ventral margin; poles rostrate; axial area linear, central area slightly ovoid or rounded; striae radiate at the centre, becoming parallel or slightly radiate toward the poles. Length 25-30 µm, breadth 4-6.5 µm, striae 14 to 22 in 10 µm. Habitat: pH 8.0, air temperature 12-20°C, water temperature 7-16°C, altitude 4950-5100 m. Present in samples: 114c, 121, 123. **This is a new record for China.**

***Encyonopsis microcephala* (Grun.) Krammer**

(Fig. 126)

Krammer (1997b: 91, pl. 143, figs 8-24).

Valves slightly dorsi-ventral with convex dorsal margin and straight or convex ventral margin; poles rostrate or capitate; axial area narrow, central area indistinct; striae slightly radiate. Length 15-22 µm, breadth 3-4 µm, striae 12 to 24 in 10 µm. Habitat: pH 5.0-10, air temperature 13.5-30°C, water temperature 11-23°C, altitude 1668-5000 m. Present in samples: 116b, 116c, 101, 109, 110, 114b,

114c, 121, 124, 125, 129, 131, 132, 133, 139. Distributed in Tibet, Sichuan, Hunan, Qinghai, Guizhou and Yunnan Provinces (Zhu & Chen, 1989, 1994 & 2000; Bao *et al.*, 1986; Wei *et al.*, 1994; Li *et al.*, 2002).

***Encyonopsis neoamphioxys* Krammer (Fig. 127)**

Krammer (1997b: 141, pl. 168, figs 6-7).

Valves dorsi-ventral, lanceolate-linear, with rostrate poles; axial area narrow, central area small; an isolated stigma on the dorsal side of the central area; striae radiate. Length 28-33 μm , breadth 5.5-6 μm , striae 10 to 18 in 10 μm . Habitat: air temperature 16.5°C, water temperature 13.5°C, altitude 2750 m. Present in samples: 135a, 135b. Distributed in Tibet (Zhu & Chen, 2000).

***Encyonopsis perborealis* Krammer (Figs 128-132)**

Krammer (1997b: 109, pl. 154, figs 1-12).

Valves slightly dorsi-ventral, linear-lanceolate with slightly convex dorsal and ventral margin; poles rostrate; axial area narrow, linear, central area absent; striae slightly radiate. Length 14-24 μm , breadth 3-3.5 μm , striae 22 to 26 in 10 μm . Habitat: pH 8.0, air temperature 12-16°C, water temperature 7-15°C, altitude 5000-5100 m. Present in samples: 121, 123. **This is a new record for China.**

***Encyonopsis tiroliana* Krammer *et* Lange-Bert. (Fig. 133)**

Krammer (1997b: 102, pl. 203, figs 10-12).

Valves slightly dorsi-ventral, linear-lanceolate with convex dorsal and ventral margin; poles rostrate or capitate; axial area linear, central area small or lack; striae radiate at the centre, becoming slightly radiate toward the poles. Length 14-18 μm , breadth 3-4 μm , striae 18 to 22 in 10 μm . Habitat: pH 5.5-8.5, air temperature 12-24°C, water temperature 7-21°C, altitude 4280-5500 m. Present in samples: 119, 121, 123, 124, 125, 133. **This is a new record for China.**

***Delicata* Krammer**

***Delicata delicatula* (Kütz.) Krammer (Figs 134, 135)**

Krammer (2003: 113, pl. 129, figs 1-30).

Valves dorsi-ventral, narrow-lanceolate with shallow-convex dorsal margin and slightly convex or nearly straight ventral margin; axial area narrow, central area small or lacking; striae radiate. Length 35-42 μm , breadth 6-7.5 μm , striae 12 to 20 in 10 μm . Habitat: pH 6.5-10, air temperature 13.5-27°C, water temperature 3-17°C, altitude 1668-5500 m. Present in samples: 118b, 109, 114b, 114c, 129, 130, 131, 134, 137. Distributed in Tibet, Jilin, Sichuan, Shanxi, Hunnan, Qinghai, Guizhou and Yunnan Provinces (Zhu & Chen, 1989, 1994 & 2000; Bao *et al.*, 1986; Liu, 1982; Gao, 1987; Zhong *et al.*, 1986; Wei *et al.*, 1994).

***Delicata sinensis* Krammer *et* Metzeltin (Figs 136, 137)**

Krammer (2003: 121, pl. 136, figs 13-20).

Valves slightly dorsi-ventral, linear-lanceolate with shallow-convex dorsal margin and nearly straight ventral margin; poles rounded and slightly dorsally bent; axial area narrow, curved, central area semifascia on the dorsal side; striae radiate. Length 30-40 μm , breadth 6-7 μm , striae 14 to 20 in 10 μm . Habitat: pH 5.0-8.0, air temperature 14-28°C, water temperature 3-18°C, altitude 1668-5500 m. Present in samples: 109, 118b, 110, 134, 136. **This is a new record for China.**

Delicata sparsistriata* Krammer*(Fig. 138)**

Krammer (2003: 121, pl. 132, figs 15-20).

Valves slightly dorsi-ventral, lanceolate with slightly convex dorsal and nearly straight ventral margin; poles narrowly rounded, axial area narrow, central area small and ventrally displaced; striae radiate. Length 22-33 μm , breadth 5-7.5 μm , striae 10 to 18 in 10 μm . Habitat: pH 7.0-8.5, air temperature 13.5-22°C, water temperature 10-20°C, altitude 4440-4750 m. Present in samples: 125, 130, 131, 134. **This is a new record for China.**

Delicata* sp. 1*(Figs 139-141)**

Valves dorsi-ventral, semi-lanceolate with slightly convex dorsal ventral margin; poles narrowly rounded, sometimes slightly rostrate; axial area narrow, central area small; one shortened striae in the middle of dorsal valve; striae radiate, becoming slightly radiate towards the poles. Length 19-29 μm , breadth 5-6.5 μm , striae 10 to 20 in 10 μm . Habitat: pH 6.5-8.5, air temperature 13.5-20°C, water temperature 11-15°C, altitude 1668-4750 m. Present in samples: 109, 130, 134.

Delicata* sp. 2*(Fig. 142)**

Valves dorsi-ventral, semi-lanceolate with slightly convex dorsal and ventral margin; poles narrowly rounded, sometimes slightly rostrate; axial area wide, lanceolate, central area large and round; striae radiate. Length 60 μm , breadth 9.5 μm , striae 16 to 28 in 10 μm . Habitat: pH 8.0, air temperature 12°C, water temperature 15°C, altitude 5100 m. Present in sample: 121.

Gomphonema* Ehrenb.**Gomphonema acuminatum* Ehrenb.****(Figs 143, 144)**

Lee *et al.* (1992: 49, pl. 9, figs 131-132); Patrick & Reimer (1975: 112, pl. 15, figs 2, 4, 7), Schmidt *et al.* (1902: 239, figs 11-15).

Valves clavate, biconstricted, expanded at the centre and constricted before dilating into a wedge shaped rounded apex; the base narrow and rounded; axial area linear, central area broad, with shortened central striae, one or more on both sides, isolated stigma on one side. Length 40-55 μm , breadth 8.5-13 μm , striae 7 to 16 in 10 μm . Habitat: pH 8.5, air temperature 18°C, water temperature 23°C, altitude 4750 m. Present in samples: 132. Distributed in Tibet, Heilongjiang, Qinghai, Hunan and Jilin Provinces (Fan *et al.*, 1998; Bao *et al.*, 1992; Zhu & Chen, 1994 & 2000; Huang, 1986; Li *et al.*, 2002).

Gomphonema acutiusculum* (O. Mull.) A. Cleve-Euler*(Fig. 145)**

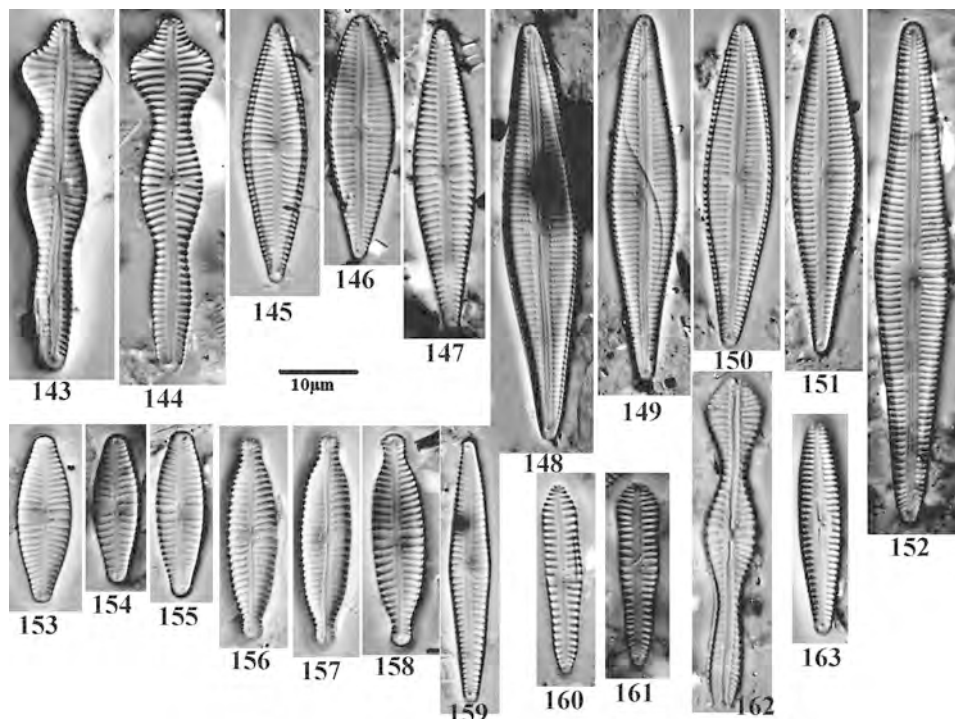
Cleve-Euler (1955: 184, fig. 1279)

Valves lanceolate with very narrowly rounded apex and base; axial area linear, broad, central area small, one short stria on one side and an isolated punctum on other side; striae radiate. Length 36-42 μm , breadth 8-10 μm , striae 10 to 20 in 10 μm . Habitat: pH 7.0, air temperature 27°C, water temperature 17°C, altitude 2350 m. Present in sample: 137. Distributed in Tibet (Zhu & Chen, 2000).

Gomphonema* sp. cf. *affine* Kütz.*(Figs 146-152)**

Patrick & Reimer (1975: 133, pl. 17, fig. 4).

Valves lanceolate-clavate with rounded apex and base; axial area linear, broad, central area small with one short stria on one side, isolated punctum on



Figs 143-163. **143, 144.** *Gomphonema acuminatum* Ehrenb. var. *acuminatum*. **145.** *Gomphonema acutiusculum* (O. Mull.) A.Cleve **146-152.** *Gomphonema* sp. cf. *affine* Kütz. var. *affine*. **153-155.** *Gomphonema americobtusatum* Reichardt et Lange-Bert. **156-158.** *Gomphonema angustatum* (Kütz.) Rabenh. var. *angustatum*. **159.** *Gomphonema* sp. cf. *auritum* Brun. et Kütz. **160-162.** *Gomphonema brébissonii* Kütz. **163.** *Gomphonema clevei* Fricke.

other side; striae slightly radiate. Length 38-73 µm, breadth 9-10.5 µm, striae 8 to 16 in 10 µm. Habitat: pH 5.0-7.0, air temperature 23-30°C, water temperature 13-18°C, altitude 1750-2380 m. Present in samples: 110, 136, 137. Distributed in Tibet, Hubei and Heilongjiang Provinces (Fan *et al.*, 1998; Zhu & Chen, 2000).

***Gomphonema americobtusatum* Reichardt et Lange-Bert. (Figs 153-155)**
 Reichardt (1999: 33, pl. 34, figs 1-18).

Valves lanceolate, clavate; apices rostrate to capitate, rounded; axial area narrow, central area transverse rectangular, short stria on one side, stria with an isolated punctum on other side; striae radiate. Length 23-31 µm, breadth 7-8.5 µm, striae 10 to 16 in 10 µm. Habitat: pH 8.0, air temperature 11-16°C, water temperature 7-17°C, altitude 5000-5700 m. Present in samples: 116a, 123, 127. **This is a new record for China.**

***Gomphonema angustatum* (Kütz.) Rabenh. (Figs 156-158)**
 Patrick & Reimer (1975: 125, pl. 17, figs 17-19).

Valves lanceolate or linear; apices rostrate to capitate; axial area narrow, central area small, one short stria on one side, stria with isolated punctum on

other side; Striae radiate. Length 21-34 μm , breadth 4-7 μm , striae 10 to 16 in 10 μm . Habitat: pH 5.0-8.5, air temperature 17-24°C, water temperature 10-20°C, altitude 1668-4950 m. Present in samples: 116a, 116c, 101, 110, 125, 131, 133. Distributed in Tibet, Hunan, Heilongjiang, Qinghai, Sichuan and Shanxi Provinces (Fan *et al.*, 1998; Zhu & Chen, 1989, 1994 & 2000; Bao *et al.*, 1986; Gao, 1987; Zhong *et al.*, 1986; Li *et al.*, 2002).

***Gomphonema* sp. cf. *auritum* Brun. ex Kütz. (Fig. 159)**

Rumrich *et al.* (2000: pl. 125, figs 1-12).

Valves linear-lanceolate; apices narrowly rounded; axial area narrow, central area small, one short stria on one side, stria with isolated punctum on other side; striae radiate. Length 23-35 μm , breadth 4.5-6 μm , striae 8 to 16 in 10 μm . Habitat: pH 8.0-8.5, air temperature 16-18°C, water temperature 7-23°C, altitude 4750-5000 m. Present in samples: 123, 132. Distributed in Tibet (Zhu & Chen, 2000).

***Gomphonema* *brébissonii* Kütz. (Figs 160-162)**

Reichardt (1999: 46, pl. 57, figs 1-10).

Valves clavate, bi-constricted, expanded at the centre and constricted into a rounded apex; base narrow and rounded; axial area linear, central area small, irregularly with shortened central striae, one on both sides with an isolated stigma on one side. Length 30-50 μm , breadth 7-9 μm , striae 8 to 14 in 10 μm . Habitat: pH 8.5, air temperature 18°C, water temperature 23°C, altitude 4750 m. Present in sample: 132. **This is a new record for China.**

***Gomphonema* *clevei* Fricke (Fig. 163)**

Krammer & Lange-Bertalot (1997: 372, pl. 164, figs 20, 21).

Length 22-30 μm , breadth 5-7 μm . Striae 10 to 16 in 10 μm . Habitat: pH 5.5-6.5, air temperature 19-24°C, water temperature 10-16°C, altitude 1668-5000 m. Present in samples: 109, 127, 133. Distributed in Tibet (Zhu & Chen, 2000).

***Gomphonema* *cymbelliclinum* Reichardt *et* Lange-Bert. (Fig. 164)**

Reichardt (1999: 36, pl. 39, figs 24-26).

Valves lanceolate; apices rounded; axial area narrow, central area small; an isolated stigma; striae radiate. Length 24-35 μm , breadth 6-7.5 μm , striae 9 to 16 in 10 μm . Habitat: pH 6.0-6.5, air temperature 19-23°C, water temperature 11-13°C, altitude 1668 m. Present in samples: 109, 110. **This is a new record for China.**

***Gomphonema* *entolejum* Østrup (Figs 165, 166)**

Krammer & Lange-Bertalot (1991: pl. 86, figs 11, 12).

Length 28-49 μm , breadth 6-7 μm , striae 10 to 18 in 10 μm . Habitat: pH 6.0-7.0, air temperature 16.5-27°C, water temperature 13-17°C, altitude 2350-2750 m. Present in samples: 110, 135a, 137. **This is a new record for China.**

***Gomphonema* *gracile* Ehrenb. (Figs 167, 168)**

Watanabe & Usman (1987: 40, pl. 11, figs 32-35), Patrick & Reimer (1975: 131, pl. 17, figs 1-3).

Valves linear-lanceolate with acute apex and base; axial area narrow, central area unilateral; an isolated stigma; striae radiate. Length 38-50 μm ,

breadth 8-9 μm ; striae 9 to 18 in 10 μm . Habitat: pH 5.0-10, air temperature 13.5-30°C, water temperature 14-25°C, altitude 1668-5500 m. Present in samples: 116a, 101, 110, 136, 124, 125, 127, 129, 130, 131, 132, 135a, 135b, 137, 138, 139. Distributed widely in China.

***Gomphonema hedinii* Hust.** (Figs 169, 170)

Patrick & Reimer (1975: 121, pl.16, figs 9a-b), Schmidt *et al.* (1925: 357, figs 13-14).

Valves linear-lanceolate; apex capitate, base rostrate; axial area narrow, central area transverse; striae irregular shortened in central area; isolated stigma; striae radiate, becoming parallel toward apices. Length 23-30 μm , breadth 6.5-8 μm , striae 8 to 16 in 10 μm . Habitat: pH 6.5-10, air temperature 13.5-24°C, water temperature 3-20°C, altitude 1668-5500 m. Present in samples: 116a, 116b, 116c, 118b, 109, 114a, 114b, 114c, 121, 125, 127, 129, 130, 131, 132, 133, 134. Distributed in Tibet and China (Hustedt, 1922).

***Gomphonema helveticum* var. *genuinum* Mayer** (Figs 171-174)

Cleve-Euler (1955: 181, fig. 1273 a, c).

Length 35-40 μm , width 6-8 μm , striae 9 to 16 in 10 μm . Habitat: pH 8.0, air temperature 20°C, water temperature 16°C altitude 4950 m. Present in sample: 116b. Distributed in Guizhou Province (Zhu and Chen, 1989).

***Gomphonema lagenula* Kütz.** (Figs 175-177)

Rumrich *et al.* (2000. pl. 133, figs 6, 7).

Valves lanceolate, clavate; apices rounded, capitate; axial area narrow, central area small, transverse rectangular with one short stria one side, stria with isolated punctum on other side; striae radiate. Length 21-34 μm , breadth 6-7 μm , striae 10 to 16 in 10 μm . Habitat: pH 5.0-7.0, air temperature 24-28°C, water temperature 14-18°C, altitude 1668-2350 m. Present in samples: 101, 136, 137. **This is a new record for China.**

***Gomphonema lateripunctatum* Reichardt et Lange-Bert.** (Figs 178-181)

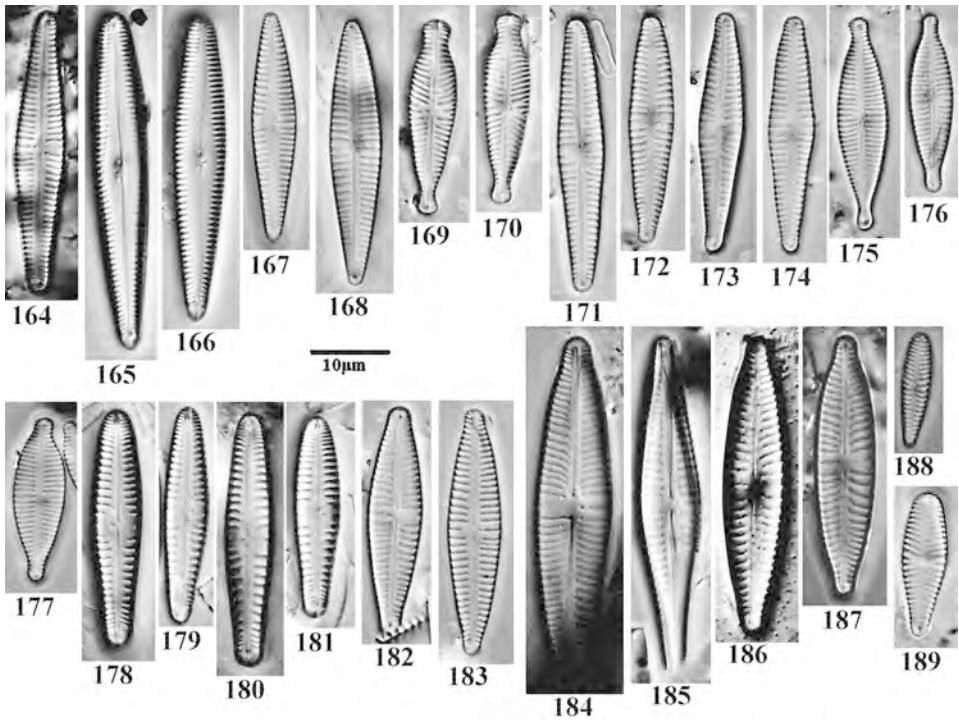
Reichardt & Lange-Bertalot (1991: 530, pl. V, figs 1-17).

Valves linear-lanceolate or clavate; apices rounded; axial area linear, central area transverse; an isolated stigma; striae slightly radiate. Length 28-38 μm , breadth 6-7 μm , striae 8 to 14 in 10 μm . Habitat: pH 5.5-8.0, air temperature 12-24°C, water temperature 10-20°C, altitude 4280-5100 m. Present in samples: 116b, 121, 125, 133, 134. **This is a new record for China.**

***Gomphonema lippertii* Reichardt et Lange-Bert.** (Figs 182, 183)

Reichardt (1999: 21, pl. 21, figs 1-15).

Valves lanceolate, clavate; apices slightly rostrate to capitate, rounded; axial area narrow, central area transverse rectangular, one short stria on one side, stria with isolated punctum on other side; striae radiate. Length 29-38 μm , breadth 7-9 μm , striae 8 to 16 in 10 μm . Habitat: pH 5.0-7.0, air temperature 27-28°C, water temperature 17-18°C, altitude 1750-2350 m. Present in samples: 136, 137. **This is a new record for China.**



Figs 164-189. **164.** *Gomphonema cymbelliclinum* Reichardt et Lange-Bert. **165, 166.** *Gomphonema entolejum* Øestrup. **167, 168.** *Gomphonema gracile* Ehrenb. **169, 170.** *Gomphonema hedinii* Hust. **171-174.** *Gomphonema helveticum* var. *genuinum* May. **175-177.** *Gomphonema lagenula* Kütz. **178-181.** *Gomphonema lateripunctatum* Reichardt et Lange-Bert. **182, 183.** *Gomphonema lippertii* Reichardt et Lange-Bert. **184.** *Gomphonema longilineare* Reichardt. **185.** *Gomphonema maclaughlinii* Reichardt. **186, 187.** *Gomphonema micropus* Kütz. **188.** *Gomphonema minutiforme* Lange-Bert. et Reichardt. **189.** *Gomphonema olivaceum* (Lyngbye) Kütz.

***Gomphonema longilineare* Reichardt**

(Fig. 184)

Reichardt (1999: 39, pl. 43, figs 1-15).

Valves linear-elliptical, clavate; apices obtuse; axial area moderately wide, central area transverse rectangular with 1-3 short stria on one side; striae radiate. Length 42-50 µm, breadth 9-11 µm, striae 7 to 14 in 10 µm. Habitat: pH 5.5-8.5, air temperature 14-24°C, water temperature 3-16°C, altitude 1668-5500 m. Present in samples: 116a, 116b, 116c, 118a, 118b, 109, 121, 131, 133, 134. **This is a new record for China.**

***Gomphonema maclaughlinii* Reichardt**

(Fig. 185)

Reichardt (1999: 22, pl. 22, figs 1-14).

Valves lanceolate or clavate with rounded head- and foot-pole; axial area linear, central area transverse; an isolated stigma; striae slightly radiate. Length 45-55 µm, breadth 8-9 µm, striae 8 to 15 in 10 µm. Habitat: pH 6.0, air temperature 23°C, water temperature 13°C, altitude 2380 m. Present in sample: 110. **This is a new record for China.**

***Gomphonema micropus* Kütz. (Figs 186, 187)**

Reichardt (1999: 34, pl. 37, figs 1-29).

Valves clavate with undulated margins; apices rounded; axial area narrow, central area small, transverse; an isolated stigma; striae radiate. Length 30-40 µm, breadth 7-8.5 µm, striae 10 to 20 in 10 µm. Habitat: pH 7.0, air temperature 20°C, water temperature 15°C, altitude 4400 m. Present in sample: 134. Distributed in Tibet (Zhu & Chen, 2000).

***Gomphonema minutiforme* Lange-Bert. et Reichardt (Fig. 188)**

Krammer & Lange-Bertalot (1991: 411, figs 20-23).

Valves clavate; apices rounded; apex are broader than base; axial area narrow, central area small, transverse; an isolated stigma; striae radiate. Length 18-25 µm, breadth 4-5 µm, striae 10 to 20 in 10 µm. Habitat: pH 7.0, air temperature 20°C, water temperature 15°C, altitude 4400 m. Present in sample: 134. **This is a new record for China.**

***Gomphonema olivaceum* (J.W. Hornimann) Kütz. (Fig. 189)**

Carter & Denny (1992: 177, pl. 4, fig. 8), Germain (1986: 123-128).

Valves clavate; apex broadly rounded and basis narrowing rounded; axial area narrow, central area rectangular; striae in central area irregular in length, striae radiate. Length 16-23 µm, breadth 5-6.5 µm, striae 10 to 18 in 10 µm. Habitat: pH 6.5-8.5, air temperature 14-30°C, water temperature 3-18°C, altitude 1668-5500 m. Present in samples: 118a, 119, 109, 134, 139. Distributed widely in China.

***Gomphonema olivaceum* var. *calcareum* (Cleve) Van Heurck (Fig. 190)**

Huang *et al.* (1998: 41, pl.90, fig.10), Hustedt (1930: 379, fig. 721).

Differs from the nominate variety by small central area, almost parallel striae and the shape of valve. Length 34 µm, breadth 7 µm, striae 9 to 15 in 10 µm. Habitat: pH 6.5, air temperature 19°C, water temperature 11°C, altitude 1668 m. Present in samples: 109. Distributed in Tibet, Heilongjiang, Qinghai, Guizhou and Jilin Provinces (Fan *et al.*, 1998; Bao *et al.*, 1992; Zhu & Chen, 1994 & 2000; Li *et al.*, 2002).

***Gomphonema olivaceoides* Hust. (Fig. 191)**

Patrick & Reimer (1975: 144, pl. 18, figs 21a-b).

Length 17-25 µm, breadth 4.5-6.5 µm, striae 9 to 16 in 10 µm. Habitat: pH 8.0, air temperature 14°C, water temperature 3°C, altitude 5500 m. Present in sample: 118a.

***Gomphonema pararhombicum* Reichardt, Jüttner et Cox (Fig. 192)**

Jüttner *et al.* (2004: 238, figs 3-9).

Valves linear-lanceolate; apex and base rounded; axial and central area forming a lanceolate space; an isolated stigma; striae radiate. Length 25-38 µm, breadth 6-8 µm, striae 10 to 15 in 10 µm. Habitat: pH 6.0-6.5, air temperature 16.5-19°C, water temperature 11-13.5°C, altitude 1668-2750 m. Present in samples: 109, 135a, 135b. **This is a new record for China.**

Gomphonema parvulum* Kütz.*(Figs 193-195)**

Patrick & Reimer (1975: 122, pl. 17, figs 7-10).

Valves clavate-lanceolate with capitate to rostrate apices; axial area narrow, central area narrow; an isolated stigma; striae slightly radiate. Length 15-32 μm , breadth 6-9 μm . Striae 10 to 18 in 10 μm . Habitat: pH 5.0-8.5, air temperature 13.5-30°C, water temperature 3-25°C, altitude 1668-5500 m. Present in samples: 116a, 116b, 116c, 118b, 119, 101, 109, 110, 136, 121, 124, 125, 127, 130, 131, 132, 133, 135a, 135b, 137, 138, 139. Distributed in Tibet, Jilin, Heilongjiang, Sichuan, Shanxi, Hunan, Guizhou, Qinghai, Jiangxi and Yunnan Provinces (Zhu & Chen, 1989, 1994 and 2000; Bao *et al.*, 1992; Fan *et al.*, 1998; Bao *et al.*, 1986; Skvortzow, 1935; Li *et al.*, 2002).

Gomphonema parvulum* var. *exilissimum* Grun.*(Figs 196, 197)**

Cleve-Euler (1955: 177, fig. 1269, d-f).

Differs from the nominate variety by lanceolate valve and denser striae. Length 35-42 μm , breadth 6-7.5 μm , striae 13 to 18 in 10 μm . Habitat: pH 5.0-6.5, air temperature 16.5-30°C, water temperature 10-18°C, altitude 1668-4280 m. Present in samples: 101, 133, 135a, 139. Distributed in Tibet and Guizhou Province (Zhu & Chen, 1994 and 2000).

Gomphonema productum* (Grun.) Lange-Bert. et Reichardt*(Figs 198-200)**

Reichardt (1999: 31, pl. 32, figs 1-18).

Valves linear-elliptical, almost symmetrical; apices obtuse; axial area moderately wide, central area transverse rectangular with one short stria on one side; striae slightly radiate, becoming radiate towards the apices. Length 26-42 μm , breadth 7-10 μm , striae 7 to 14 in 10 μm . Habitat: pH 6.0-8.5, air temperature 12-23°C, water temperature 3-15°C, altitude 2380-5500 m. Present in samples: 110, 118a, 119, 121. Distributed in Tibet, Sichuan, Shanxi, Hunan, Guizhou and Yunnan Provinces (Zhu and Chen, 1989, 1994 and 2000; Wei *et al.*, 1994; Gao, 1987; Bao *et al.*, 1986).

Gomphonema protractum* Kociolek et Stoermer*(Fig. 201)**

Kociolek & Stoermer (1990: 342, pl. 7, figs 10-12).

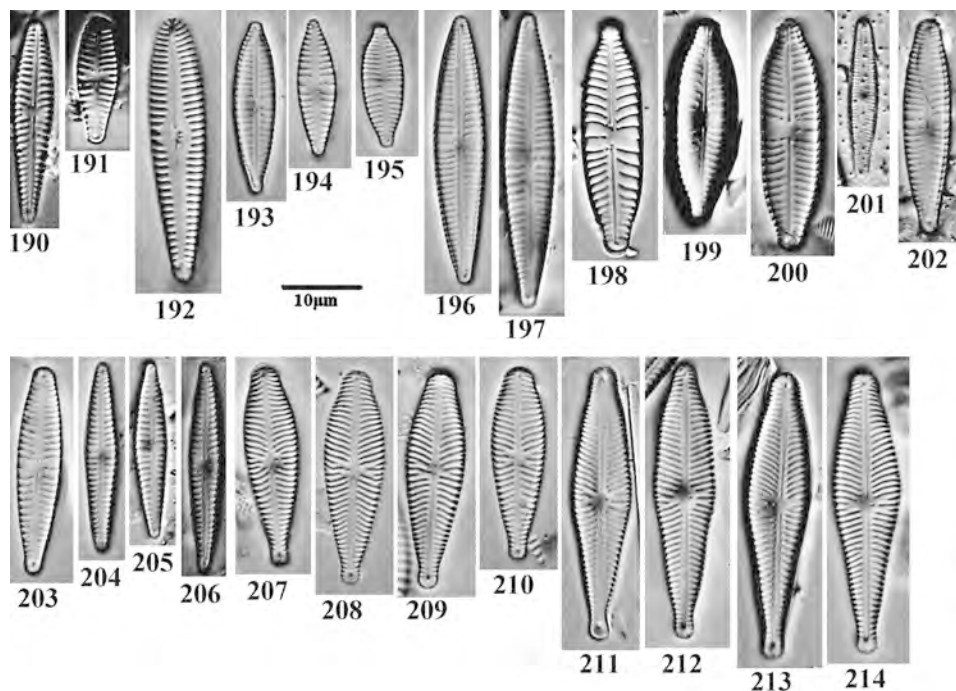
Valves linear-clavate; apices rounded; axial area narrow, central area rounded; striae parallel to radiate. Length 16-22 μm , breadth 3-4 μm , striae 18 to 24 in 10 μm . Habitat: pH 8.0, air temperature 12°C, water temperature 15°C, altitude 5100 m. Present in sample: 121. **This is a new record for China.**

Gomphonema punae* Lange-Bert. et Rumrich*(Figs 202, 203)**Rumrich *et al.* (2000: 140, pl. 129, figs 1-14).

Valves clavate; apex bluntly rounded, base rounded; axial area narrow, central area transverse rectangular with one short stria on one side and a stria with isolated punctum on other side; striae radiate. Length 15-30 μm , breadth 4-6 μm , striae 10 to 16 in 10 μm . Habitat: pH 5.5, air temperature 24°C, water temperature 10°C, altitude 4280 m. Present in sample: 133. **This is a new record for China.**

Gomphonema* sp. 1*(Figs 204-206)**

Valves lanceolate to linear-lanceolate with a narrowly rounded apices; axial area narrow, central area small; one shortened striae in one side of the central area, an isolated stigma on the other side; striae slightly radiate. Length 16-29 μm , breadth



Figs 190-214. **190.** *Gomphonema olivaceum* var. *calcareum* Cleve. **191.** *Gomphonema olivaceoides* Hustedt. **192.** *Gomphonema pararhombicum* Reichardt, Jüttner et Cox. **193-195.** *Gomphonema parvulum* (Kütz.) var. *parvulum*. **196, 197.** *Gomphonema parvulum* var. *exilissimum* Grunow. **198-200.** *Gomphonema productum* (Grunow) Lange-Bert. et Reichardt. **201.** *Gomphonema protractum* Kociolek et Stoermer. **202, 203.** *Gomphonema punae* Lange-Bert. et Rumrich. **204-206.** *Gomphonema* sp. 1. **207-210.** *Gomphonema* sp. 2. **211-214.** *Gomphonema* sp. 3.

3.5-4.5 µm, striae 10 to 18 in 10 µm. Habitat: pH 8.0-8.5, air temperature 16-18°C, water temperature 7-23°C, altitude 4750-5000 m. Present in samples: 123, 132.

***Gomphonema* sp. 2 (Figs 207-210)**

Valves lanceolate to linear-lanceolate with a rounded headpole and narrowly rounded footpole, sometimes undulate margin; axial area narrow, central area rectangular; striae irregularly shortened in the central area; an isolated stigma; striae radiate, becoming parallel toward apices. Length 38-43 µm, breadth 8-9 µm, striae 9 to 16 in 10 µm. Habitat: pH 8.5-10, air temperature 13.5-18°C, water temperature 14-23°C, altitude 4750 m. Present in samples: 129, 130, 132.

***Gomphonema* sp. 3 (Figs 211-214)**

Valves lanceolate to linear-lanceolate with a rounded headpole and narrowly rounded footpole; axial area narrow, central area rectangular; striae irregularly shortened in the central area; an isolated stigma; striae radiate, becoming parallel toward apices. Length 26-30 µm, breadth 7.5-8 µm, striae 9 to 16 in 10 µm. Habitat: pH 5.5-10, air temperature 13.5-24°C, water temperature 10-23°C, altitude 4280-5000 m. Present in samples: 116b, 116a, 125, 127, 129, 130, 132, 133.

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